# SILICON CHIP

FEBRUARY 2012
$9.30 27/02/12
SILICON CHIP
Top
FEB 12
1202
240112 7
201001024400
NDC 03956
Greensborough Plaza Ne
008-002-005
$9.30* INC GST NZ$11.90 INC GST

Use a SmartDrive motor as a ... MOTOR!
SEMTEST SEMICONDUCTOR TEST SET
IT'S DAZZLING!
SEMTEST: Check all your Semiconductors
10W LED Floodlight
low to make pro-quality PCBs at home – using a laminator!

# Back to work with Hardcore Electronics

FEBRUARY 2012

## STEREO COMPRESSOR KIT

Refer: SC Magazine Jan 2012

Compressors are useful in eliminating the extreme sound levels during TV ads, "pops" from microphones when people speak or bump / drop them, levelling signals when singers or guitarist vary their level, etc. Kit includes PCB, processed case and electronic components for 12VDC operation. 12VDC plug pack required - use MP-3147 $17.95.

**KC-5507** $59.95

## LED HEADBAND MAGNIFIER

This magnifying headset leaves both hands free and can be worn over prescription or safety glasses. The head strap is fully adjustable and locks into position and the lens assembly can be swivelled up out of the way when not in use.

- Built-in LED work light
- 1.5x, 3x, 8.5x or 10x magnification
- Requires 2 x AAA batteries

**QM-3511** $29.95

## DEOXIT CONTACT CLEANER & REJUVENATOR - PEN STYLE

Simple cleaners wash away dirt, grime, and dust from your expensive equipment but are often ineffective at cleaning tough oxidation and metal sulphide contamination. This product will not only clean, but it will help restore your equipment to its original condition, improving its performance.

**NS-1430** WAS $19.95 $9.95 SAVE $10.00

Limited stock. Not available online.

## 4 TRAY TOOL/STORAGE CASE

Each compartment has a 233 x 122 x 32mm, 13 compartment storage box for small items with dividers that can be removed to accommodate larger things. All the hinges and catches are the durable pintle type and the top tray has a generous 265 x 160 x 85mm space for ancillary items.

- Size: 270(W) x 260(H) x 150(D)mm

**HB-6302** WAS $16.95 $12.95 SAVE $4.00

## ATTENTION KIT BUILDERS

**Kit Back Catalogue**

**If you can't find the kit you are looking for, try the Jaycar Kit Back Catalogue. Our central warehouse keeps a quantity of older and slow-moving kits that can no longer be held in stores. A list of kits can be found on our website. Just search for "kit back catalogue".**

## XLR CONNECTORS - AMPHENOL

These premium quality XLR plugs and sockets feature solder type cable termination for minimum signal loss.

**4-Pin Male PP-1044**
WAS $11.95 NOW $4.95
SAVE $7.00

**5-Pin Male PP-1072**
WAS $17.95 NOW $6.95
SAVE $11.00

**5-Pin Locking Female PS-1076**
WAS $24.95 NOW $9.95
SAVE $15.00

From $4.95 SAVE $7.00

Limited stock. Not available on-line.

## DIGITAL CAPACITANCE METER

High accuracy and extensive ranges to cover any requirement, zero adjustment display.

- 0.1pF to 20,000µF
- Holster included
- Banana to alligator clip leads
- Size: 190(L) x 90(W) x 35(D)mm

**QM-1572** WAS $59.95 $34.95 SAVE $25.00

Limited stock. Not available online.

## STIRLING ENGINE

A Stirling engine is a machine that converts heat into mechanical energy by alternately compressing and expanding air. The expanding air acts on a piston to provide mechanical force: you simply heat up the air chamber, give the flywheel a whirl and away it goes. Made in Germany, our Stirling engine is beautifully engineered from stainless steel, brass and a genuine timber base.

- 2 ball bearings
- Suitable for ages 12+
- Adult supervision recommended
- Working speed: 2,500RPM
- Working time: Approx. 30 min
- Size:156(L) x 108(W) x 70(H)mm

**YM-2921** WAS $299.00 $249.00 SAVE $50.00

Limited stock. Not available online.

## CHIP QUIK SMD REMOVAL KIT

Chip Quick is a low melting point solder product that maintains the molten state of a row of pins. It even works on PLCC chips. Essential rework tool for anyone who uses SMD components.

- 1cc lead-free alloy kit will remove 8 - 10 SMD PLCC chips.

**NS-3050** WAS $39.95 $29.95 SAVE $10.00

Limited stock. Not available online.

## ULTRASONIC ANTIFOULING UNITS

We've been selling the D.I.Y kit successfully for over a year now, and the growing consensus is that ultrasonic antifouling systems appear to work very well. The special frequencies seriously deter marine growth of the various organisms that choose to use your boat as a home, reducing the frequency of slipping for messy, expensive antifouling treatment. These completely manufactured units are straight forward to install. Power is supplied by 12VDC and a low voltage cut-out feature is also included, which protects the boat's batteries from being over discharged. Each unit includes a control box (5m lead) and transducers (10m lead each), and a comprehensive installation & instruction manual. More details and specification can be found on our website.

Two versions available:

Dual Output, suitable for vessels up to 14m (45ft)
**YS-5600** $899.00

Quad Output, suitable for vessels up to 20m (65ft)
**YS-5602** $1199.00

From $899.00

NOTE: Larger vessels can simply use multiple units. Twin hull vessels will require double the recommendations above.

## MULTIFUNCTION WATER QUALITY METER

Tests pH, temperature, total dissolved solids (TDS), electrical conductivity (EC), conductivity factor (CF) and oxidation reduction potential (ORP). The backlit LCD can display pH plus one other parameter at a time. Applications include agriculture and aquaculture, science, education, research, food and beverage production, fish hatcheries, water conditioning and recycling etc. 9VDC mains adaptor, charger, buffer solution, probes with holder and carry case included.

**QM-1675** WAS $449.00 $299.00 SAVE $150

FREE solution (QM-1673) with each purchase

Limited stock. Not available online.

## MAKE YOUR OWN CLOCK

This accurate clock movement is ideal for hobby projects or repairing that old family mantle clock. The clock includes three different sets of hands and requires 1 x AA battery.

- Self starting motor
- Includes sweep second hand

**XC-0100** $12.95



Jaycar Electronics

Better, More Technical

# Contents

SILICON CHIP
Vol.25, No.2; February 2012 www.siliconchip.com.au

## Features

**14 Converting The F&P SmartDrive for Use As A . . . Motor**
*Recycled smart drive washing machine motors can be found in wind turbines, water turbines and many other types of generators. Here's how to use a Fisher & Paykel SmartDrive motor as . . . a motor – by Nenad Stojadinovic*

**36 DCC: Digital Command Control For Model Railways**
*DCC is becoming increasingly popular. Here's a quick rundown on how it works – by Leo Simpson*

**76 Homebrew PCBs Via Toner Transfer**
*Want to make good-quality PCBs at home? Here's how to do it using a cheap laminator, a laser printer and a few low-cost materials – by Alex Sum*

## Projects To Build

**20 A Really Bright 10W LED Floodlight**
*This bright LED floodlight rivals halogens but consumes much less power. It's compact, efficient and easy to build – by Branko Justic & Ross Tester*

**24 Crystal DAC: A High-Performance Upgrade**
*This new, high-end DAC board can be installed in our Hifi Stereo DAC project (Sept-Nov 09) without any major changes – by Nicholas Vinen*

**42 SemTest: A Discrete Semiconductor Test Set; Pt.1**
*Versatile unit can test LEDs, diodes, transistors, Mosfets, SCRs and PUTs for gain (if applicable), voltage breakdown and leakage. You can even test IGBTs and Triacs! – by Jim Rowe*

**64 Simple 1.2-20V 1.5A Switching Regulator**
*It's small, efficient and boasts a very low drop-out voltage, little heat generation and electronic shut-down – by Nicholas Vinen*

## Special Columns

**58 Serviceman's Log**
*You've got to have a good system in place – by the Serviceman*

**70 Circuit Notebook**
*(1) Traffic Light Sequencer; (2) Electric Fence Tester; (3) How To Operate Multiple 433MHz UHF Remote Switches; (4) Quadrature Decoder For Motor Feedback; (5) Eye-Level Display For Bathroom Scales; (6) Guitar Practice Amplifier; (7) SudoMate For Sudoku Puzzles; (8) Rapid Fire Dexterity Game*

**86 Vintage Radio**
*The 1930s Palmavox 5-valve superhet; Pt.1 – by Maurie Findlay*

## Departments

2 Publisher's Letter
4 Mailbag
57 Product Showcase
91 Summer Showcase
94 Ask Silicon Chip
98 Order Form
103 Market Centre

A Really Bright 10W LED Floodlight – Page 20.

Crystal DAC High-Performance Upgrade Board – Page 24.

SemTest Discrete Semiconductor Test Set – Page 42.

1.2-20V 1.5A Switching Regulator – Page 64.

SILICON CHIP
www.siliconchip.com.au

*Publisher & Editor-in-Chief*
Leo Simpson, B.Bus., FAICD

*Production Manager*
Greg Swain, B.Sc. (Hons.)

*Technical Editor*
John Clarke, B.E.(Elec.)

*Technical Staff*
Ross Tester
Jim Rowe, B.A., B.Sc
Nicholas Vinen

*Photography*
Ross Tester

*Reader Services*
Ann Morris

*Advertising Enquiries*
Glyn Smith
Phone (02) 9939 3295
Mobile 0431 792 293
glyn@siliconchip.com.au

*Regular Contributors*
Brendan Akhurst
Rodney Champness, VK3UG
Kevin Poulter
Stan Swan
Dave Thompson

SILICON CHIP is published 12 times a year by Silicon Chip Publications Pty Ltd. ACN 003 205 490. ABN 49 003 205 490. All material is copyright ©. No part of this publication may be reproduced without the written consent of the publisher.

Printing: Hannanprint, Noble Park, Victoria.

Distribution: Network Distribution Company.

Subscription rates: $97.50 per year in Australia. For overseas rates, see the order form in this issue.

Editorial office:
Unit 1, 234 Harbord Rd, Brookvale, NSW 2100.

Postal address: PO Box 139, Collaroy Beach, NSW 2097.

Phone (02) 9939 3295.

Fax (02) 9939 2648.

E-mail: silicon@siliconchip.com.au

ISSN 1030-2662
Recommended and maximum price only.

# Publisher's Letter

## Loud television commercials will continue to be annoying

Most people find TV advertising annoying. That annoyance may range from complete intolerance, to the point where the sound must be muted every time an advert comes on, to more occasional annoyance with advertising which is extremely puerile, banal or just offensive. I have to admit though, there are times when an advert flashes up and I want to hear what it is about, only to find that someone else in the room has a trigger finger on the remote and has already muted it or flicked to another channel. Now that is annoying!

However, a more common reason for wanting to mute the sound is that the commercials are simply too loud and jarring. This happens all too often and is not confined to the commercial channels; SBS and ABC can be equally guilty.

Now all those aggrieved viewers will be interested to know that the problem is not confined to Australia but is worldwide. Apparently, the pressures of commerce universally cause advertisers or TV networks to try and force their messages upon the viewers. So a recent press release from the American Federal Communications Commission (FCC) may come as refreshing news.

Responding to years of complaints that the volume on commercials was much louder than that of the sponsored TV programs, the FCC has passed the Commercial Advertisement Loudness Mitigation Act. What a mouthful! This is intended to make sure that the sound levels are the same for commercials, news and entertainment programming. The FCC said that cable and satellite TV companies, as well as local broadcasters, will have to make sure that the volume on commercials is kept in check. The rules will come into effect in December 2012.

Would such legislation work in Australia? I am thinking, "Probably not." While advertising is annoying I don't think I would be keen to see the Federal Government legislate to this effect. The appropriate regulating body would no doubt be the ACMA (Australian Communications & Media Authority) and they already have evidently too much to do so they are not likely to enforce a new set of regulations. Besides, why do we need possibly hundreds of pages of government bureacratese pontificating about a problem that most viewers have pretty much solved? They simply kill the channel with the remote – often with malice aforethought.

In fact, when TV broadcasters wind up the wick on commercials they are doing themselves no good at all and are giving viewers more reasons to go elsewhere for their entertainment. Most people I know are watching less and less TV as the years go by.

The stupid part about this is that the advertising agencies and their clients must already know that loud commercials are annoying – or at least those for competing products are! So why compound the problem when pushing their own products? I could argue also that most commercials are repeated so often that they inevitably all become annoying and irrelevant anyway, no matter what the message. And the more annoying they are, the more counter-effective they become.

So next time you are particularly annoyed by the loudness of a TV commercial, don't think that perhaps there "oughta be a law!" We all should realise that when government legislates against some practice, it rarely has the positive outcome that was intended and often has many unintended consequences.

I think the quiet and unspoken revolt is far more effective. If the station keeps broadcasting loud commercials, turn the TV off. Then go read a book or magazine.

**Leo Simpson**

OCEAN CONTROLS

Helping to put you in Control

**Control Equipment**

**New Arduino Uno R3**

In addition to all the features of the previous board, the Uno now uses an ATmega16U2. This means faster transfer rates and more memory. No drivers needed for Linux or Mac (inf file for Windows is needed and included in the Arduino IDE)
**SFA-103 $35+GST**

**9 Degrees of Freedom Sensor Stick** It includes the ADXL345 3 axis accelerometer, the HMC5883L magnetometer, and the ITG-3200 gyro. The 'stick' has a simple I2C interface and a mounting hole for attaching it to your project
**SFS-203 $99+GST**

**Bipolar Stepper Motor** Nema17 motor with a holding torque of 4.4Kg-cm. Fitted with a dual shaft this motor suits 3D printers like the RepRap and Makerbot cupcake machines.
**MOT-121 $52+GST**

**Electronic Thermostat** The N322 thermostats have two relay outputs which can be configured for heating or cooling or a number of different alarm modes. Four front panel keys allow easy configuration. Comes with a 2m waterproof NTC thermistor sensor which can be extended to 50m.
**CET-001 $65+GST**

**Heating and Cooling Bimetallic Thermostats**
These dead-simple DIN -rail mount thermostats are usually used to switch a heater or fan on or off in a cabinet. The normally open contacts can switch up to 10A 250VAC
**Cooling HEC-005 $29.95+GST**
**Heating HEC-010 $29.95+GST**

**Solid State Relay Controller**
Control a Solid State Relay or Motor Speed controller with a 0-5V or 4-20mA signal using our KTA-269 Pulse width modulator generator board.
**KTA-269 $59.95+GST**

**Fieldlogger Datalogger**
Customers are amazed at the number of features packed into this datalogger. 8 universal analog inputs, 2 relay outputs, 8 Digital inputs, color screen, Ethernet, USB and RS485 connections, memory card, free software the list goes on and only priced at
**NOD-003 $1099+GST**

**Temperature and Humidity Controller**
The N322RHT has 2 relay outputs which can be configured independently as control or alarm, either for temperature or relative humidity. A humidity and temperature probe is provided.
**CET-007 $195+GST**

**Rotary Encoder**
A 500 Line 8 mm Internal Hollow Dia quadrature rotary encoder with A, B and Z NPN-style outputs. 12 to 24 V DC powered.
**IBE-101 $147+GST**

**Labjack U3**
USB data acquisition unit with 16 flexible I/O Each I/O can be a 12 bit analog input, digital input or output. 2 of the lines can also be configured as counters and timers. All Windows software and drivers, Labview drivers included.
**LAJ-021 $149.95+GST**

**4-20mA Loop Powered Panel Meter**
4 Digit fully programmable by front panel keys
IP65 Box.
**CMI-005 $149+GST**

**Mounting Hubs**
Universal mounting hubs are designed to work with most 4 mm motor shafts.
**MOA-011 $11.95+GST**

**Pressure Transmitters**
We are now stocking a range of 4-20mA 2-wire gauge pressure transmitters with ranges from 0-2Bar to 0-250Bar. These rugged transmitters feature a stainless steel construction and accuracy of 0.5%. Suitable for non-corrosive media such as air, water etc.
**AXS-150 $149+GST**

**M18 Capacitive Proximity Switches**
These sensors can detect almost any liquids and solids. A control on the back of the sensor adjusts the triggering threshold. Fitted with a LED indicator and powered by 10 to 30 VDC
**IBC-001 $49 +GST**

**Temperature Transmitter**
With a range of −10 to 125degC and a 4 to 20mA output this transmitter can be used to measure the temperature of rooms and cabinets.
**KTA-267 $44.95+GST**

**7 Digit Counter**
This self powered counter (internal battery) can count up to 9999999 contact closures. Retains data at least 10 years. Reset by front button or remote switch
**CHN-007 $39.95+GST**

**Waterproof Temperature Sensor**
This PT100 RTD sensor is mounted in a 30 mm long stainless steel probe. The 3 wire Silicone lead is 1 m long. Temperature range is -50 to 200 °C.
**CMS-001 $49.95+GST**

**DIN Rail Fuse Terminal**
These terminals include an LED that lights when the fuse is blown, allowing quick diagnosis of problems. Suitable for 24V Power.
**TRM-043 $2.49+GST**

**Ocean Controls**
**Factory 3/24 Wise Ave**
**Seaford Vic**
**Ph: 03 9782 5882**
**www.oceancontrols.com.au**

# MAILBAG

Letters and emails should contain complete name, address and daytime phone number. Letters to the Editor are submitted on the condition that Silicon Chip Publications Pty Ltd may edit and has the right to reproduce in electronic form and communicate these letters. This also applies to submissions to "Ask SILICON CHIP" and "Circuit Notebook".

## New Freeview channel from the Seven network

Recently, the Seven network introduced channel 74, TV4ME, on the digital network. I had no problem tuning it in to all my devices but when I tried on my parents set-top box which is only 15 months old, I could tune it in but was not able to get picture or sound.

The STB is an OLIN HVBT-3200, purchased from a reputable retailer. Fortunately, on the back of the device was a hotline number, so I called it and explained the problem. The operator told me they had received a memo from the Seven network, informing them that the new channel will be broadcast using the latest MPEG4 encoding as it has excellent SD video quality for the increased video compression used. This will allow for more digital channels within the 7MHz bandwidth. Unfortunately, this particular STB does not have MPEG4 decoding and it's only 15 months old!

This is only one device I know of but how many older units allow MPEG4? All current devices will decode HD but it's a case of will they decode all SD? How long will it be before the other networks go this way? I understand the prices of STBs and TVs are always on the way down but if one spent good money a few years ago, especially on a TV to get HD, is it fair that we have to now consider the backward step of the appropriate SD decoder?

At home, I did a comparison recording of 7SD and 74. 74 has over three times more compression. A 3.5-minute recording from 7SD used 135MB, while the same time on 74 only used 41.5MB.

**Simon Kareh,**
**Penshurst, NSW.**

## More complexity in cars is undesirable

I have just read the Mailbag letter in your January 2012 issue about mandating technological improvements in cars. The author must be dreaming. Mechanically, modern good-quality cars are extremely reliable. Unfortunately, this reliability is to a degree compromised by the complexity of electrical and computer systems.

The last thing you would want is to further reduce reliability by adding the suggested systems. The average auto-electrician can just about cope with simple electrical faults but is often completely lost on modern car computer systems.

**Poul Kirk,**
**South Guildford, WA.**

## Mandating car safety features not cost-effective

Congratulations to Michael Tobin (Mailbag, January 2012) on having some ideas about road safety. But all laws which cost people money or curtail their freedoms should be evidence-based, not just someone's idea of what might work. It's doubly so for road-safety policies which should be determined by a scientific process; by coming up with theories then proving or disproving them with evidence that it works.

Just because someone has a driver's licence doesn't mean their opinions on road safety are worth anyone else listening to, as hard as it is to convince some people otherwise; common sense isn't good enough. Road safety is engineering and lives depend on getting it right.

Road engineering also has to be cost-effective. A life is valuable but it is not infinitely valuable. So whatever is done has to generate more value in lives saved than it cost. There are a million ways that technology could reduce road deaths but most of them would cost more than they are worth,

## Fire risk in solar panel installations

On 23rd December 2011, the National Electrical and Communications Association (NECA) expressed concern at a report released by EnergySafety entitled "Electrical safety of grid-connected solar installations in Western Australia". The report indicates that 12% (approximately 2500) of domestic solar installations in WA carry a significant risk of fire. In view of this, it is clear that solar installation regulations require a dramatic overhaul.

Presently there is no clarity as to who is regulating the solar industry. The State and Federal Governments both have rules and regulations, which often overlap and contradict each other.

Solar installers are not required to be licensed; only those persons who do the electrical wiring need to be licensed electrical contractors. The majority of regulation of the solar industry is done by the Clean Energy Council, which is a private corporation that has been given extraordinary powers by the Federal Government. NECA believes that all solar installers should have an electrical contracting licence.

The vast majority of electrical contractors who perform solar installations are trained and experienced. The fact that unqualified operators are able to participate in our industry will only ensure that unsafe practices continue. NECA has raised this with the Federal Government repeatedly but they have said it is not a priority for them.

If anyone has concerns that their solar installation is unsafe, they should call their licensed electrical contractor to arrange a safety inspection.

**Kyle Kutasi,**
**NECA Western Australia,**
**Perth, WA.**

AS9120A Certified Distributor

au.mouser.com
Distributing semiconductors and electronic components for design engineers.

Authorized Distributor




# Find It Here. Faster.

The Newest Products for Your Newest Designs™

- Global Authorized Distributor of Electronic Components
- 450+ Industry-Leading Suppliers
- No Minimum Order and Same-Day Shipping
- World-Class Local Language Technical Support
- 17 Website Languages and Currencies Available
- 2 Million Parts Online

au.mouser.com | australia@mouser.com

**Active Components**
+61 (2) 9893-9400 (New South Wales)
+61 (3) 9775-4778 (Victoria)
+64 (9) 443-9500 (Auckland)
+64 (3) 355-4545 (Christchurch)
+64 (4) 915-9500 (Wellington)
mouser@activecomponents.com
www.activecomponents.com

**X-ON Electronic Services**
+61 (7) 3394-4490 (Brisbane)
+61 (3) 9574-9044 (Melbourne)
+61 (8) 9358-9358 (Perth)
+61 (2) 9748-7622 (Sydney)
mouser@x-on.com.au
www.x-on.com.au

MOUSER ELECTRONICS
a tti company

Mouser and Mouser Electronics are registered trademarks of Mouser Electronics, Inc. Other products, logos, and company names mentioned herein, may be trademarks of their respective owners.

DYNE
INDUSTRIES PTY LTD
Now manufacturing the original ILP Unirange Toroidal Transformer

- In stock from 15VA to 1000VA
- Virtually anything made to order!
- Transformers and Chokes with Ferrite, Powdered Iron GOSS and Metglas cores
- Current & Potential Transformers
DYNE Industries Pty Ltd
Ph: (03) 9720 7233 Fax: (03) 9720 7551
email: sales@dyne.com.au
web: www.dyne.com.au

## Mailbag: continued

often because the scenario they are designed to prevent doesn't actually occur very often.

You wouldn't believe it from the media headlines but most people, about 99%, do not die on the roads; they die of something else. Road deaths aren't even in the top 10. So there are a million other things that could be done with the money that would save more lives.

**Gordon Drennan,**
**Burton SA.**

### Ozone sanitisers not mentioned

I was somewhat taken aback regarding your answer to "Pool sanitisers don't work" (Ask Silicon Chip, page 100, January 2012), as no mention was made regarding ozone treatment.

As one of the leading manufacturers of ozone generators in Australia I would like to point out that ozone in conjunction with either chlorine or bromine and in fresh or salt water is regarded as the best, fastest and safest way to sanitise pools, spas or in fact any contaminated water. The ozone breaks back down to oxygen when used as an oxidiser and leaves no residual harmful chemicals and only a minimal (0.1ppm) amount of chlorine or bromine is required to act as a residual sanitiser when the ozone and pump are turned off.

The only stipulation we make is that the ozone generator should be in use at all times when there are swimmers in the water. I wholeheartedly agree that most pool sanitisers don't work, with some of them being downright dangerous.

**Terry Quayle,**
**Santer Industrial Products,**
**Maddington, WA.**

### Portable audio recorder wish-list

I was very interested to read the letter from S. Williamson, "Another vote for a portable audio recorder" (Mailbag, page 13, January 2012), as I also feel the need for such a device.

At present, I am using a Thomson "Lyra" USB Flash MP3 player with voice recording that I purchased about three years ago. The recording facility is monaural at 8kHz sample rate, 32-bit floating point, according to the Audacity analysis of the files, but the unit has room for a claimed 141 hours of recording when no other files are loaded.

There appears to be some form of limiting in the recording, as there is no audible clipping on high-level voice recordings, nor does Audacity show any clipping of the waveforms, although I have not tested this aspect exhaustively. As one would expect, the quality is really "voice only" but is satisfactory for recording choir and light opera rehearsal sessions.

In my opinion, it compares very favourably with early cassette recorders but without the wow and flutter and background noise those units exhibited. The recorder is comparable in size to the ubiquitous MP3 players and has its own USB plug to allow direct connection to a PC.

While it is invaluable in its own right, I would like something offering much better quality, with facilities for external stereo microphones, along the lines described by Mr Williamson, so that I could do some serious music recording.

**Greg Mayman,**
**Adelaide, SA.**

### Idealistic greens have no technical knowledge

Please don't blame the politicians for the problems with solar panels over-supplying the grid. I have spoken to two Green pollies. Both have humanities and law backgrounds (one is a Senator for Queensland) and the other teaches history at undergraduate level. Neither had a clue as to what you were talking about.

The candidate I met at a party thought there were several problems preventing the wide-scale adoption of solar electricity. She thought that the authorities were just being difficult in not completely re-designing the grid. Please understand these people are very idealistic. To me they seem to be lacking in knowledge of basic electrical engineering especially in the field of power distribution.

I think that the electrical engineering profession has not been heard in the political process. Surely, engineering is a discipline that should be better represented if not in parliament, then in the wider debate and certainly in public education. Time and again in this country we seem to be doing everything back to front. If re-designing and re-engineering the power supply grid is necessary for the widespread adoption of solar panels, then why weren't we told this in the first place?

It is obvious that householders understand the need and benefits of installing these systems but none of us had any idea that the daytime voltages in our streets would soon be going "sky high".

**Chaim Lee,**
**Toowoomba, Qld.**

### Pouring cold water on the Publisher's Letter

I want to pour some cold water on the Publisher's Letter in the December 2011 issue.

From my experience at grass roots level there will be no stressing of the grid resulting in wholesale damage to domestic appliances, TVs, computers etc caused by the installation of domestic solar panel systems. In my experience, I have at times received a small cheque and at other times made a small payment on receiving my electricity account. This means I am generating about one-third of the energy I am using with the other two-thirds supplied from the grid. My system is 1.8kW.

My two neighbours who have 1.5kW systems do not receive a cheque which indicates they are generating about one quarter of their daily usage, with three quarters being supplied from the grid.

I doubt that daytime domestic consumption is low, due to washing machines, clothes driers, ironing, food preparation, coffee machines, large screen TVs, computers and so on.

**Norman Showell,**
**Keiraville, NSW.**

### Domestic solar panels do not make electricity grid unstable

Despite the assertions in the Publisher's Letter (December 2011) and the Australian newspaper on 13th October, rooftop solar PV installations do not cause instability in the electricity network. The net effect at the current level of rooftop PV generation (~1% of total power generation) cannot even offset the increase in domestic air-conditioning load (currently increasing at the rate of ~30% per annum). On average, the effect that rooftop PV has on the network is positive, as it produces maximum output on hot, dry sunny days when the air-conditioning load makes it difficult to keep the domestic system voltage above the minimum limit set by AS 60038 (216V).

All solar PV grid-tied inverters installed in Australia must conform to AS4777, which means that they must automatically disconnect if the supply voltage exceeds 255V. It has been that way from day one. The grid-tied inverter must also disconnect if the supply frequency falls outside the limits of 50Hz ±2Hz.

The Australian mains supply voltage specified in AS 60038 is 230V with a tolerance of +10% -6%, so the maximum voltage should be 253V. 253V is the nominal level set by a distributor that you keep at least one example of an early valve black and white set, a solid-state one and a colour set.

The next point is how will you provide a signal for a valve black and white set with no AV inputs and which only tune the VHF channels? This can be provided by a VHF (but not UHF) RF modulator which can still be obtained. Another method is to use a redundant VCR (they are vintage too) with an output on VHF. Many of the later ones only have a UHF output which does not suit early valve TVs. Some set-top boxes do have an RF output but this is invariably on UHF.

So I do encourage interested readers to think about this and do something about retaining our vintage TV equipment very soon, before it is too late.

**Rodney Champness,**
**Mooroopna, Vic.**

### Analog TVs are rapidly disappearing

Whilst restoration and operation of the old black and white analog TV receivers is not a major interest of vintage radio buffs, it will become more so as analog TV disappears. Already many regional areas of Australia are now exclusively digital. And in the purely digital areas, many local councils, encouraged by the government, have allowed people to discard their analog TVs for free at the recycling depots. Many of these sets are in perfect working condition. Some analog TVs have been kept in operation using set-top boxes, as I have done.

There are a couple of points I want to make before all our vintage televisions end up in landfill. If you are at all interested in vintage TV or what will become vintage, even if only vaguely interested, I suggest


# Australia's Best Priced DSOs

Shop On-Line at emona.com.au

**RIGOL DS-1052E 50MHz**

- 50MHz Bandwidth, 2 Ch
- 1GS/s Real Time Sampling
- USB Device, USB Host & PictBridge

**ONLY $439** inc GST

**RIGOL DS-1102E 100MHz**

- 100MHz Bandwidth, 2 Ch
- 1GS/s Real Time Sampling
- USB Device, USB Host & PictBridge

**ONLY $769** inc GST

**RIGOL DS-1202CA 200MHz**

- 200MHz Bandwidth, 2 Ch
- 2GS/s Real Time Sampling
- USB Device & USB Host

**ONLY $1,422** inc GST

**Sydney** Tel 02 9519 3933 Fax 02 9550 1378
**Melbourne** Tel 03 9889 0427 Fax 03 9889 0715
**Brisbane** Tel 07 3275 2183 Fax 07 3275 2196
**Adelaide** Tel 08 8363 5733 Fax 08 8363 5799
**Perth** Tel 08 9361 4200 Fax 08 9361 4300
email testinst@emona.com.au
web www.emona.com.au

EMONA

## Mailbag: continued

### Reactions to the January 2012 issue

Perhaps I've misunderstood Werner Hahling's letter (Mailbag, page 4) but he seems to be saying that there's no cost saving if everyone reduces their electricity consumption, because tariffs would then go up to compensate for the reduced total consumption. That would of course be true if the total cost of generation and transmission (consisting of operating costs, maintenance of existing infrastructure and planning and implementation of replacement and additional infrastructure) was constant. Divide a constant total by a diminished base and of course, the rate per kWh goes up.

But surely the logical fallacy here is obvious? Generation and transmission costs are hardly constant. At the very least, feeding less coal into a power station is a saving. At the extreme, if everyone including industry really did use significantly less power, then shutting down an aging power station, and not replacing it, is a biggie. And money not spent on additional transmission capacity to support growth that's no longer there is, well, money not spent.

Concerning the Publisher's Letter, I certainly agree that energy policy is a mess but I'd be happy if it was at least a more consistent mess. If we're to have a carbon tax, the government should drop all subsidies of feed-in-tariffs and mandated "green energy" targets and let the carbon tax, through the market, do its job.

Either they believe in the power of market forces (hence the tax) or they know better and try to pick winners. Attempting to do both is an unhelpful distortion. And if there's to be a carbon tax, it should be applied evenly, consistently, to all sources of carbon dioxide (or equivalent units of methane etc). Taxing some sources ("evil big polluters") and not others is another distortion.

On the electronics front, it was nice to see an article introducing the Arduino concept. It nicely answered "what's all the fuss about?"; except maybe for PICAXE users, who might still be wondering. There are certainly quite a few of these "rapid prototyping" solutions, with low barriers to entry, out there now. The "mbed" platform (see **www.mbed.org**) is another. And the Maximite fits this category, especially the mini version from the November 2011 issue, along with its clones. The success of these platforms shows that there's a real hunger out there for simple, yet powerful and flexible, solutions.

I'm reminded of some of the talk when microcontroller-based projects started appearing in electronics magazines such as SILICON CHIP. Some saw them it as not being "real" electronics – a little too easy compared with blocks of TTL and 555s. There was a sense that some of the "art" of electronics was being lost to newcomers who lacked deep knowledge. I see some of the same talk now, mainly about Arduino – almost a resentment of its ease of use.

Opening up electronics to more people has to be a good thing, as is any tool that saves time and doesn't cost a lot of money. But for me, I'll keep designing with PICs and even programming in assembler, because it's fun. Electronics as a hobby isn't all about doing things the easy way.

Finally, it was great to see a simple radio article. A lot of projects these days are quite specialised and complex. It's so nice to see something with general appeal and fun! Some people might ask, who build a radio when you can buy really cheap ones? They just don't get it!

Keep up the good work!

**David Meiklejohn,**
**Macquarie Fields, NSW.**

at the transformer output to ensure that the consumer at the end of a long line gets 216V or greater at maximum load. However, it is generally accepted that these limits are sometimes exceeded for short periods. Outside the metropolitan areas (in areas with no solar PV), I have recorded short-term voltages as low as 210V and as high as 265V.

Up to the year 2000, the nominal supply voltage in Australia was 240V. In 2000, the nominal voltage was changed to 230V in a move towards world standardisation but upper and lower limits were only minimally changed to avoid disruption to existing equipment. The intent is to drop the average voltage from 240V to 230V over a period of time. During this transitional period, the average voltage can be expected to exceed the nominal 230V but equipment connected to the network is required to operate on voltages within the range 216V to 253V.

As the electricity network transitions from centralised generation to distributed generation with the assistance of smart grids, the industry is tracking and adjusting for these changes. You can be assured that, despite Australia starting somewhat later than the rest of the developed world in implementing these changes, we are closely monitoring what is happening elsewhere and adjusting our thinking accordingly. We will learn from their mistakes and their successes, just as we did with the original implementation of colour TV.

Just as the stone age did not end because of a shortage of stones, the fossil fuel age will not end because of a shortage of fossil fuels. We know the planet will be uninhabitable if we burn all the fossil fuels but we do have other solutions to our energy requirements available. Rather than say "it ain't gonna happen", why not say "how can we make it happen?".

You might like to look at this commentary from Giles Parkinson, which is an excellent counter to the Australian newspaper article. It is also backed by the energy regulator and solid academic research: **http://www.climatespectator.com.au/commentary/its-time-smarter-grid**

**Brian O'Neill,**
**Bongaree, Qld.**

*Comment: there would be many days throughout the year when solar panel systems would generate at close to their maximum output while there was not a corresponding high air-*

*conditioning load. It stands to reason that on these occasions, solar generation could easily push the line voltage up to the maximum of 255V, at which point the solar systems would be being progressively disconnected and no longer giving their owners the benefit of their output, as can be seen from the letter below.*

### Over-voltage from solar electric systems

Everyone loves free energy from the Sun. Every bright sunny day brings more savings from the electrical energy we produce and use ourselves, and from the surplus we sell back to the grid.

I have operated a 1.5kW solar system for two years and have occasionally found the inverter displaying "an event has occurred" error. The inverter disconnects from the grid and tries to reconnect. Finding this, I switch off the unit, wait a short time and switch the unit back on. This usually puts the unit back on line.

What is an event? As per AS4777, the inverter will stop within two seconds should the grid voltage be lower than 210VAC or higher than 255VAC. The inverter will stop within one second should the frequency of the grid be lower than 47Hz or higher than 53Hz.

The solar power inverter incorporates two functions to detect and prevent "islanding" operation. This is important when the output of the inverter and the power consumption

### Comment on the energy white paper

Though I probably don't comprehend the breadth of issues contained in the Federal Government's energy white paper, I will freely comment on the text style and departure from understandable and concise English language. It's never been anything new for governments to obfuscate or even struggle with massaging a document for the masses or industry in general as this one seems intended.

I support the Editor in his condemnation (Publisher's Letter, January 2012) but his restraint is too kind. It is neophyte jive-speak and has no place in documents that should read straight from the government to the people – all the people in my view.

I don't wish to speculate on what air-headed individual or agency planned or drafted the document but 329 pages of such waffle is an insult, regardless of the real content which is likely a readable 100-pages deeply buried in trendy jive.

I put it to Mr Ferguson and the readers that he would have difficulty keeping a straight face reading it in Parliament or even to Caucus. Perhaps he could get lucky and the members would doze off or move to the lounge. Surely, his department will make some apology for even this sample of the paper's bungling, pretentious twaddle. Perhaps too, the author would care to "transition their career path to a more leveraged, goal-focused sphere of interactions . . ." or similar "hype" activity as I have read elsewhere.

**Ian Finch,**
**Urunga. NSW.**

## Mailbag: continued

### Solar panels don't always deliver claimed output

We had a 1.9kW solar system installed in mid 2011 and were pleased with the result. Being mid-winter, I was impressed with the output from the system even in cloudy and rain conditions. Outputs of several hundred watts were normal when there was no direct sunlight.

I waited with anticipation, as the Sun rose ever higher and the summer approached, expecting the peak output, as read on the solar inverter, to climb during the middle of the day to 1.9kW but it never did. Our panels face north and there is no shading. The best our 1.9kW system does in December, at noon with no cloud, is 1.6kW.

I rang the solar company and was told a variety of things from, "Yes, you should get 1.9kW" to "No, you should not". One person even told me that you lose 18% from the solar panels to the inverter and 15% from the inverter to the mains connection, for a total loss of 30%. I said why not use thicker cable to cut down the loss but the conversation then went into a mixture of fact, fiction and plain just did not know what he was talking about.

I reported the system faulty and a person came out to check the system. We have 10 panels in two banks of five. He was able to reconnect the two banks so their outputs read separately on the inverter and the outputs were the same. So this showed most likely that there was no fault.

He also reiterated the story that a 1.9kW system does not produce 1.9kW. So why is it advertised as a 1.9kW? The consumer only wants to know what he is getting. Yes, there is 1.9kW of solar panels, so the marketing should say, a 1.9kW solar panel array producing at peak 1.6kW and I would have known what we were getting. After all, if you buy a one litre of soft drink you expect one litre, not a 1-litre bottle containing 0.8 litres.

**Will McGhie, VK6UU,**
**Gooseberry Hill, WA.**

of the home are well balanced and the voltage or the frequency of the grid does not change during a power failure, resulting in the power failure not being detected. If this occurs, a passive system that detects a jumping voltage phase and an active system that detects frequency shift stops the inverter operation within two seconds.

There are conditions that are monitored by the inverter and are required by Australian standard 4777 to monitor and to disconnect the inverter from the grid when certain conditions occur. The inverter will shut down when the power from the grid becomes abnormal or fails. This will provide safety to the people working on the power lines and protect the home circuits and solar power inverter.

One morning, I found my inverter showing an F-00 fault code. In my case, I have a Sharp JH-1600E model inverter. After several restarts, the problem hadn't gone away so I referred to the installation and operation manual. In the Sharp operation manual the F-00 code indicates "Utility abnormal – Utility over-voltage".

I then took a multimeter and checked the voltage at my power points. It indicated 252V; close enough to 255V to cause the problem. The meter isn't calibrated and the 255V may have been set low in the inverter.

I then called SEQEB and reported my problem: plenty of sunlight and my solar panel system/inverter is not working. It is displaying a "utility over-voltage" fault. SEQEB were brilliant. Within two hours, I had personnel at my home to check the supply voltage and home wiring. That was about 12:30PM and the inverter had reconnected itself to the grid and was fully functional. About 4:30 PM, another team arrived and left monitoring equipment in my home, on the connecting power pole and on the transformer further down the street. Both teams assured me that the supply voltage was within the specified range; it being 248V and 242V respectively when they monitored it.

Well, what was the problem? The electrical grid is built to supply maximum demand or peak demand and there are times when demand is not that high. Unfortunately, this aligns with the time that our solar energy output peaks, between 10am and 1pm.

Normally, when demand for electricity drops, the supply voltage rises but

# ARM® compilers

We really believe in the freedom of choice. Experience the powerful **mikroC**, **mikroBasic** and **mikroPascal** compilers for ARM® Cortex™ -M3 microcontrollers. Intuitive IDE makes your development easy, and settings seamless. Over **500 library functions** with examples and a comprehensive help file will help you get your project done quickly. Compilers feature smart data types and mighty **SSA optimization** which increases execution speed and reduces the code size by 20-40%. **Pay only once** for the compiler of your choice and we will give you **Free support** and **Free upgrades** until the end of the product lifetime. There are no other ARM® compilers on the market that offer so much at such a price. It's the **best value for money.** You will have a **strong and reliable ally** in development.

starting at $199^{00}

**strong ally.**

MikroElektronika
DEVELOPMENT TOOLS | COMPILERS | BOOKS

**GET IT NOW**
**www.mikroe.com**

**ANTRIM TRANSFORMERS**
manufactured in Australia by
**Harbuch Electronics Pty Ltd**
harbuch@optusnet.com.au

Toroidal – Conventional Transformers
Power – Audio – Valve – 'Specials'
Medical – Isolated – Stepup/down
Encased Power Supplies

**Toroidal General Construction**

Comprehensive data available:
www.harbuch.com.au

**Harbuch Electronics Pty Ltd**
9/40 Leighton Pl, HORNSBY 2077
Ph (02) 9476 5854 Fax (02) 9476 3231

## Mailbag: continued

still remains within the Australian Standard 4777 for supply to homes. With the advent of solar-panel, grid-connected, power systems which generate a higher voltage than the utility supplies in order to drive excess generated energy into the grid, this results in the voltage at the home climbing above the abnormal voltage level of 255V. In my case, the inverter disconnects from the grid and fails to produce any energy at all. This is only for a limited time but the system is non-productive during that time.

Why has this happened? Lots of Australians are now signing up for the solar energy solution. As more properties try to feed excess electrical energy back into the grid, then the voltage on our side of the transformer rises and solar panel inverters drop off because they sense the abnormal condition.

The SEQEB employees who attended my home advised that I contact the installer of the system and have them raise the voltage level at which the over-voltage sensor functions in my inverter. This is a worrying solution. SILICON CHIP has published several letters on the effect of over-voltage on consumer equipment that is rated at 230V. In this case, we have artificially raised levels of voltage which occur regularly and are sustained within solar-powered communities.

The problem is an imbalance in the load cycles. Solar energy is highest when demand for electricity is at a low point. The inverter voltage must be at a higher level than the utility voltage in order to push excess power back into the grid. When the voltage level reaches the predetermined value, the inverter disconnects from the grid until the voltage level drops again. Other solar panel inverters in the immediate area may drop off at a higher voltage and these will remain active and productive.

The electricity suppliers are aware of the problem. As more people buy into the solar energy scheme, the bigger this problem becomes. It was something they had never considered but has shown itself as more people buy into the scheme.

There is no solution, yet.

**Garry Powell,**
**Willowbank, Qld.**

### Extended warranties can be worthwhile

I wish to comment on Michael Ong's letter titled, "Galloping technology can make extended warranties not worthwhile", (Mailbag, page 10, January 2012). I must disclose the fact that I do have a financial interest in extended warranties being purchased on consumer equipment. I half own and run a electronics repair business in regional Victoria.

A high percentage of our work comes from warranty and extended warranty repairs. But I don't think this will affect what I have to say, as I only wish to present the facts as we see them. I can only offer this information in regards to televisions, microwave ovens, DVD players and audio products. Extended warranties on other equipment may be different.

Firstly, buyers should be made aware of the terms and conditions of an extended warranty before the purchase, as is the case with any insurance scheme. When extended warranties are taken out on these products, it needs to be viewed that the product will be covered for manufacturing defects (as with standard manufacturer warranty) within the covered time frame. In the event that a repair is too costly, the extended warranty company will then arrange for a suitable replacement item, usually from the original place of purchase.

The replacement item will match the customer's original item in regard to its specifications and features etc. For example, if the customer originally purchased a 127cm 3D plasma TV with internet functions and the TV was un-

### Old power paradigm does not work

Solar panels are disrupting our electricity supply but they are not "another instance of the impracticality of the Green's advocacy [of] renewal resources". Rather they are just another sign that the old paradigm of base-load generator, transmission network and user is no longer suitable for the modern world. The increasing load of domestic air-conditioning has put the present system under a great deal of strain at peak times and the introduction of electric cars will kill it off. Nuclear power is a base-load system and will not help.

The choices are rotating blackouts or a system redesign which will probably be known as the "smart grid". This will be a disruptive technology whereby a nationalised electricity supplier will be able to control all major devices in the home and be able to remotely switch off devices such as air conditioning to balance the load. They may also take power from your electric car at peak times and replace it later.

The smart grid will be expensive and difficult to implement but I do not see an alternative other than a slow migration to third world conditions, or an electricity network only for the rich.

**Mark Baker,**
**South Perth, WA.**

repairable (unlikely), the TV would be replaced with at least another 127cm TV with 3D and internet functions. Therefore they are no worse off – in fact they could end up with a TV that has extra functions compared to their original (due to the fast and ever-increasing features on new TV sets).

So people should take the view that when purchasing extended warranties, they are not insuring to an exact dollar value but to specifications, etc.

Michael Ong paints a rather poor picture of the whole process regarding making a claim. When the customer purchases an extended warranty they are usually given a warranty claim card which advises them on how to make a claim. This is normally as easy as ringing a 1800 or 1300 number.

The customer's information is first verified and then a claim is raised. The extended warranty company then refers the customer to an approved repairer, as well as sending the customer's details to the repairer. The repairer would normally make contact with the customer within 24-48 hours.

Depending on the repairer's work load, the customer's item would normally be assessed within one week of the claim being raised. Then, depending on parts availability, the customer may have their repaired item back within one to two weeks but more often than not within three weeks.

Michael seems to be painting a worst case scenario, especially when he refers to the Christmas season. People have to take some holidays and in this industry it is normally only during the Christmas period when repairers close down. But this is normally only for one or two weeks anyway. Parts supply from the manufacturers shuts down during this time as well. I think most people expect that if something "non-essential" was to break down during a holiday season, that it would take longer to get it repaired.

To finish up I must say that purchasing an extended warranty really does make financial sense. We see the proof of it every day here at work. With most items, it normally only takes one warranty claim and the customer's extended warranty has more than paid for itself! Our view is that the average life of a new LCD or plasma TV is realistically only about five years. So by purchasing an extended warranty for up to a total of five years, the customer can rest assured they will be covered for the full life of the TV.

**Erik Atkinson,**
**Neilborough, Vic.**

*Comment: it should be noted that new regulations have recently been introduced which mean that consumers may not have to rely on extended warranties in order to get redress for some appliance failures.* **SC**

## PICAXE & Arduino: each have their merits

It wasn't that long ago that SILICON CHIP extolled the virtues and the DIY flexibility of the PICAXE and certainly there have been many kits designed around them. I also know of some semi-commercial car projects designed using PICAXEs and I am currently using two from a car forum.

The January 2012 issue of SILICON CHIP also presents and promotes the Arduino system for the hobbyist and apparently it's been around for longer than a lot of people realise. As I love my hobby and designing useful gadgets for cars and home etc, I have been thinking that I should learn some programming and broaden my abilities to design small useful projects. But which one?

I guess what I'm asking is which has the easier learning curve? Which is the most flexible as far as incorporation into audio, video, control, gadgets etc? Is one considerably more expensive than the other to "play with" and learn? Which has the most support or are they about the same? Is it possible to find pre-designed circuits/projects to make more for one than the other?

**Shaughan Syme,**
**Manly Vale, NSW.**

*Comment: PICAXE and Arduino both have their advantages and drawbacks. Arduino has a greater range of associated products and a vast user community. Both systems are easy to program but the approaches are different.*

*An internet search will reveal the vast range of products and prices.*

# SmartDrive Motor

## Converting a Fisher & Paykel Washing Machine Motor

by Nenad Stojadinovic

**Recycled smart drive washing machine motors have been used in countless projects. They can be found in wind turbines, water turbines, and every other type of generator imaginable. This article takes a radical new direction and uses a Fisher & Paykel SmartDrive as . . . *a motor.***

**Why would you want to use** a SmartDrive as a motor? Possibly you drooled at the possibilities presented by the pan-cake motor used in our eBike article featured in the November 2011 issue.

But that motor has a maximum power output of a few hundred watts, depending on how its controller is programmed.

What if you could use a recycled motor of the same general configuration but with a power output which might peak at 1kW or more?

The SmartDrive used in Fisher & Paykel washing machines is just such a motor. In fact, it is the only such motor which you can pick up either free from roadside clean-ups (ie, in discarded washing machines) or cheaply from recycling centres.

Of course, the SmartDrive is already a motor. What's the point in converting a motor into a motor? Well, apart from its potentially high power output, this motor can be smoothly controlled over a very wide range, up to 1200 RPM.

In Fisher & Paykel washing machines, the SmartDrive dispenses with a gearbox and runs both the wash/rinse cycles and the spin cycles.

But aside from the fact that the SmartDrive motor runs on awkwardly high voltages, it is a class of machinery that comes perilously close to being a computer peripheral, or at least a symbiotic component of a computer.

In this case, the computer is firmly built into a washing machine and having to build a big white box into every project can put a cramp on any young tech's style.

| Coil Input | Hall Outputs |
|---|---|
| | Y B G |
| A+ B- | 0 0 1 |
| A+ C- | 0 1 1 |
| B+ C- | 0 1 0 |
| B+ A- | 1 1 0 |
| C+ A- | 1 0 0 |
| C+ B- | 1 0 1 |

**Table 1: the six-step commutation sequence with Hall Effect outputs.**

### Those clever Kiwis

You have to hand it to the Kiwis: the Fisher & Paykel "SmartDrive" is certainly a clever device. In an era where washing machines were powered by conventional single phase induction motors driving a gearbox, the introduction of a microprocessor-controlled, direct drive motor was a great innovation. It has been proved in untold numbers of washing machines over the years and there are now recycling centres full of machines that have been scrapped but still having a perfectly serviceable motor.

The mountains of SmartDrives laying around have not been missed by the tech community and there are countless versions of every type of generator using the SmartDrive as a core.

To our knowledge though, there have not been any devices featuring the SmartDrive as a motor. This is no surprise; at the first sight of a motor with three fat power cables and no less than five control leads, you quickly realise that using it in your particular application might not be a 5-minute conversion.

The SmartDrive can be thought of in two ways: as a huge stepper motor wired in a 3-phase star configuration with a fixed stator (the central non-rotating part) and a hub (the rotor) with embedded magnets.

The stator consists of 42 poles (each a

**The major components in a Fisher&Paykel SmartDrive motor. Top left is the magnet hub, top right the stator, centre is the drive shaft and at the bottom are the retaining plates and nut.**

coil with a laminated steel core) and is 250mm in diameter. The hub has 56 magnets embedded in plastic and with hidden steel laminations to complete the magnetic circuit.

Or you can regard it as a variable speed, synchronous AC motor or a 3-phase permanent magnet motor. It is also known as brushless DC (or BLDC).

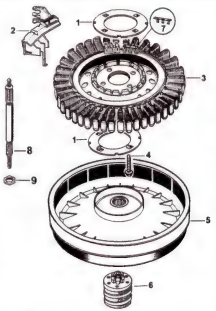
It is not an induction motor. Typical induction motors that run on 3-phase 415VAC have no permanent magnets. Instead they have a series electromagnets arranged in a circle, each connected to a separate phase of mains power, to produce a rotating magnetic field. The magnetic field then induces currents in the rotor which consequently generates its own magnetic field, and the interaction of the magnetic fields then drags the rotor around.

An induction motor always has "slip" which is the difference between the speed of the rotating magnetic field (the "synchronous" speed) and the actual motor speed.

3-phase permanent magnet motors are driven by DC and are completely dependent on their driver, without which they sit there and smoke. The motors have wound coils like the induction motor but those coils are energised by DC from a microcontroller.

As noted above, the process is very much like a stepper motor (see Fig.1) and is referred to as electronic commutation.

Note that each winding is polarised north at one step and south at another so that a full cycle has three phases multiplied by two polarisations which equals six steps. The drive sequence is thus called a 'six step commutation sequence' and is as given in Table 1 – ignore the Hall Effect column for the moment.




**Exploded view of the motor, from the F&P service manual. Most of these parts can be seen in the photo above.**

And that's why it is very easy to use a SmartDrive as a generator and so very difficult to use as a motor.

In a generator, the force supplying the rotation (be it from a wind or watermill, etc) simply swings the magnets past the wound coils to generate a voltage in the classic way which we all desperately swotted up before the final year 12 science exam.

Pick up and rectify the generated power as necessary and you're done.

Driving the motor is a vastly more complex matter of monitoring the exact position of the rotor as it goes around and switching current to the appropriate winding at exactly the right instant.

There are two main ways of monitoring the rotor position. Small motors generally monitor the voltage in windings that are not currently energised, the idea being that a rotor magnet will go past the winding and generate a little pulse

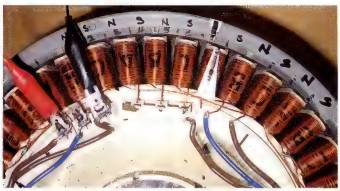
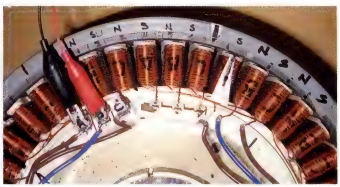


**Fig.1: the first steps from Table 1 starting from zero at A+, B-. Note that the relevant polarity can be seen from the position of the alligator clips. A positive voltage makes the relevant winding a south pole, for example A+, B- makes the A winding south and the B winding north.**



of voltage that can be detected by the controller.

A bit of fancy maths and the controller will have a very good idea of the rotor position but only once the motor is moving. Without rotor movement there are no voltage pulses so starting up can be a bit problematic.

Larger motors use Hall Effect sensors and these little fellows will report the rotor position all the way down to zero speed.

Modern sensors used in motors are minuscule surface mount chips that output say 5V when facing a north pole and 0V when facing south.

## First catch your hare SmartDrive

Having said that dumped washing machines are available in huge piles, I have to admit that I couldn't find one to scavenge and ended up placing a wanted ad in the local free classifieds web site.

That did the trick but I have to warn anybody following this path that one is likely to trigger an avalanche that is not easily stopped.

It seems that everybody knows somebody who has junk to be gotten rid of and is very happy to find someone who is happy to do it, especially for free.

**Fig.2: each strip consists of four magnets. You can just see the lines between them.**

My wife threatened dire consequences and so I ended up with only three complete motors, a very nice pump from a commercial dishwasher, a wood lathe that I later turned into a centrifuge, a refrigerated air dryer and a compressor powered not one but two 15kW motors (don't ask!).

On reflection, it may be easier to simply ring a washing machine repairman and offer to buy a motor – the going price is around $30 – or else keep an eye on the appliance section of the classifieds.

eBay is perhaps another source but you'll probably find anyone who has removed a SmartDrive motor to put on eBay knows that it is worth a few bob (eg, $50-$60!).

The SmartDrive is classed as an "outrunner", meaning that the outside of the motor rotates and is thus the rotor. Tipping the machine onto its side and spinning the plastic rotor, you will see the washing drum rotating in unison. The rotor has a total of 56 magnets and the magnets are contained in strips that are magnetised NSNS (see Fig.2).

Having removed the rotor you will see the stator which is secured by four self tapping bolts.

If you count them, the stator appears to consist of 42 wound coils but closer examination shows that they are really three coils that are each made up from 14 coils

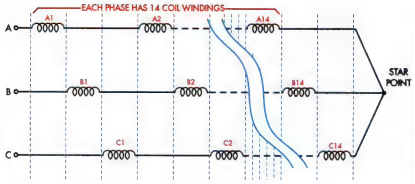



**Fig.3: each phase is fourteen coil windings in series terminated together at a star point. Normally these drawings portray the windings in a star formation (like Fig.7).**

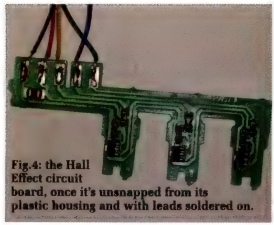


**Fig.4: the Hall Effect circuit board, once it's unsnapped from its plastic housing and with leads soldered on.**

connected in series (see Fig.3) and terminated in a star point.

Motors are made up this way to decrease their speed and increase their torque. With 56 magnets and 42 coils, each step is tiny and a sequence of six steps will only take the rotor around by a fraction of a turn (look closely at Fig.1). But the torque will be high as each energised coil winding will be attracting a magnet that is only a small distance away.

Don't think that the SmartDrive is slow though; the story goes that during development the motor was tested for maximum speed and resulted in a load of laundry being turned into confetti!

## Disassembly

Removing the stainless shaft is accomplished by undoing all of the nuts you can see and pushing the shaft out. It only takes a gentle tap with a soft mallet to get it moving and if you find that it won't go, keep looking for more nuts around the shaft.

There is a little carrier for the Hall sensors. I found it was easy to take off once the rotor was removed and it simply slides out to reveal the circuit board as shown in Fig.4.

## Stepping Motor

Once you have the motor mounted so that it will rotate, it's time to take it for a basic test run.

Fig.1 shows the input terminals arbitrarily marked as A, B & C and I also went around and labelled all of the coils in the same way.

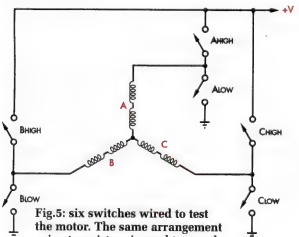



**Fig.5: six switches wired to test the motor. The same arrangement using transistors is used to run the SmartDrive as a stepping motor or as a full BLDC motor.**

I used a series of three 12V batteries to give 36V and applied power to the input terminals in the order shown in Table 1, where A+, B- means to connect A to positive and B to negative.

If you follow the sequence, you will find that the motor steps smartly around and you may also find that you get a bit of a zap from the terminals. That's called inductive kick back and now you know what that term means in a way that you'll find hard to forget!

Standing back and considering what you've just done, you'll realise that you have effectively driven the SmartDrive as a stepping motor; a very useful device in its own right.

Clearly, nobody wants to stand around swapping leads all day but everything else is in place, so the only barrier between you and a high-powered stepping motor is to find some way to drive the motor electronically.

A schematic version of what is desired is shown in Fig.5. Simply closing switches A(high), B(low) will cause the motor to take the first step on Table 1 and then opening B(low) and closing C(low) will take the next step and so on.

Reversing the order of switching will make the motor run in reverse.

Building up the schematic using real switches will give you quite a handy little motor tester but most people will want to replace the switches with Mosfets and drive them with a suitable microcontroller, perhaps an Arduino or Picaxe.

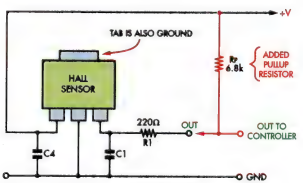



**Fig.6: circuit diagram of the Hall Effect sensors. Resistor $R_P$ is added to pull up the Hall chip's open-collector output.**

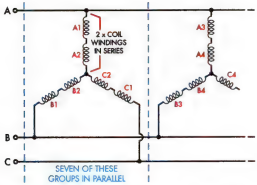



**Fig.7: this is a series-parallel connection. The coil windings are cut and joined to give a group of two coils in series and then wired together to form seven groups in parallel.**

I never had the need so I didn't do it – I've pulled apart enough copiers and printers to have a good supply of powerful stepping motors (big copiers now have BLDC motors too!).

It shouldn't be too hard to find a suitable H bridge stepping motor driver, though (eg, SILICON CHIP, April 2011 Circuit Notebook).

In fact, there is nothing to stop you hacking the original washing machine controller and driving the Mosfets with your own micro.

A warning about voltages: you must not try to use the SmartDrive as a stepping motor at the original voltage! The motor is made to run at some 200VDC and it needs this voltage to run the motor at high speed.

Stopping the motor with high voltage still applied will result in much smoke. For stepping applications, even fairly fast stepping, you will find that 48VDC is more than adequate.

Having said that, stepping motors can also be used as brakes and I recommend starting with perhaps 12-24V to give a good compromise between strong braking and overheating the motor.

## Closing the loop

To run the SmartDrive as a fully fledged BLDC motor, the next part to be addressed is the hall sensor board.

Referring again to Fig.4, you will see that the sensors require a voltage supply (red and black wires) and output their signals on the blue, green and yellow wires. I found that the sensors are open collector, meaning that they are effectively open circuit until a magnetic south pole is brought up to the face of the IC.

To run an open collector circuit, a pull up resistor is needed and the complete circuit is shown in Fig.6, with components C1, C4 & R1 being originally present on the board.

It would be easy enough to solder the pullup resistor onto the original board but I ended up making a super simple extension board with a scrap of Veroboard so I could get my multimeter onto it more easily.

Building shouldn't take more than a half hour or so and then you're ready to test.

Simply apply any reasonable voltage to the power leads, say 12V, and measure the voltage at each output while applying a small magnet to the Hall sensors. By alternating the magnetic poles, you should see the output voltage swing between approximately 12V and 0V.

For interest, you might like to reassemble the motor and run through the manual test sequence while noting the hall voltages. If all is well, you should get the results of Table 1 with '0' being 0V and '1' being 12V.

## Motor driver

The last step is to select a suitable motor driver. I originally thought of using the driver that was build into the washing machine but in the end decided that it was more trouble than it was worth.

For a start, the washing machine driver runs on full mains voltage and I wanted a system that would run on 36 or 48V. It is possible to rebuild all of the various power supplies but there is a fair bit of work involved.

The final nail in the coffin was the fact that the central processor appears to run the whole show, including all of the motor functions. The processor would run my motor but I would have to put up with any machine powered by the motor going through periodic wash, rinse and spin dry cycles!

In the end finding a suitable driver turned out to be a fairly simple task. Realising that the SmartDrive is a fairly typical and increasingly common BLDC motor, it was a matter of finding a class of machinery that used such a motor and discovering what they used as a driver.

The answer turned out to be electric vehicles, especially electric mobility devices. The driver I bought will handle 36V and 50A for a total of maybe 1500W output, once a bit is subtracted for losses. There is a slightly more powerful version available that runs 50A at 48V but that was rather more than I needed.

As is increasingly common, the driver is Chinese made and I found the original version on **www.made-in-china.com**.

A hunt around using the world's favourite search tool will turn up legions more; the only fly in the ointment being that most suppliers are located in China and the Chinese are not big on credit cards and like to ship orders via containers on ships.

I bought a few units and can offer them to readers for $149 plus a few dollars for shipping – see the list of sources at

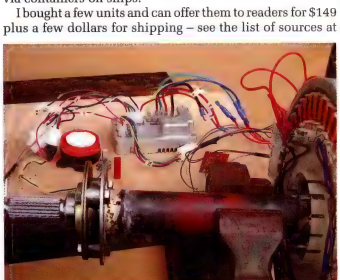


**Fig.8a: complete system, ready to run. I built the bearing housing to suit a particular application but most people simply chop out the entire Nylon bearing housing from the bottom of the washing machine drum and strap it down with U bolts.**

the end of this article. I'm also in the process of ordering a 60V and 240V version and if you're interested, drop me a line at **contact@energy1000.com.au**

For the intrepid soul, there is quite a good selection of drivers available on eBay.

The sellers are generally folks who sell a wide variety of goods and so have no product knowledge or factory info available but with the procedures outlined in this article, it should be relatively straightforward to sort out any combination of controller and motor that you might encounter.

Just don't try to drive a SmartDrive motor with a driver intended for a 200W bicycle!

## Putting it all together

One of the biggest problems I see being wrestled with on the discussion groups is the matching of a (generic) driver with a (different generic) motor.

Even the best manufacturers are notoriously short on information and there is most certainly no universal colour coding system for the drive and sensors.

The general approach is 'trial and smoke', with hot lists of 'Motor X works with Driver Y' being gleefully circulated once a working combination is found.

The driver I used (see Fig.8b) dispenses with all that unpleasantness by offering a self calibration function. Even more amazingly, it works!

By simply activating self calibration and first pulling the motor backwards and then forwards, the micro gets enough information to sort out the coil to Hall Effect sensor phasing and with a twist of the throttle, away it goes. Gotta love this modern technology!

Self calibration also makes wiring very easy. The driver comes with pre-wired plugs that are nicely labelled and the only thing to be careful of is to wire the Hall Effect power supply from the driver to the correct leads on the Hall Effect board (have another look at Figs. 4 and 6).

I then wired the rest of the Hall Effect leads as shown in Fig.4 to the same colour leads on the driver and then randomly assigned the fat yellow, blue and green power leads to motor phases A, B & C in that order (have a close look at Fig.1). The fat black and red leads are then obviously the 36V power supply.

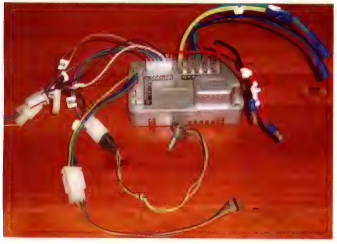


**Fig.8b: generic Chinese driver with the leads separated into their functional groups. In front are the Hall Effect sensor leads with the same colour coding as Fig.4. The throttle pot is at front and the fat yellow blue and green leads at top right are power to the motor.**

## Components and further information

Bearing housings, various parts, windmill blades and all sorts of good information can be found at **www.thebackshed.com/windmill** and also **www.ecoinnovation.co.nz/**

Motor drivers of all sorts can be obtained from Millenium Energy Pty Ltd. The driver used in this article is available for $149 at time of writing.
Email: **contact@energy1000.com.au**

Chinese manufacturers web site having every type of product imaginable: **www.made-in-china.com**

I used a 5kΩ pot as the throttle but nice twist-grip throttles are readily available from eBay or some SILICON CHIP advertisers.

The driver supplies 5V and ground to the pot and the 0-5V control signal then comes off the pot wiper. Again, all quite simple – and most manufacturers will supply at least a rudimentary wiring diagram.

You will find that the motor will only run fairly slowly, which is to be expected as the coil windings are originally intended for mains voltage and a puny 36V has trouble convincing them to magnetise at any great rate.

## Series, parallel or both?

The solution is to realise that the coils are all connected in series and for lower voltage applications it is entirely possible to connect groups of them in parallel.

The process to do it was covered by Glenn Littleford in SILICON CHIP in a series of articles starting in December 2004 (**siliconchip.com.au**) and can also be found at **www.thebackshed.com/windmill/Contents.asp**

The final arrangement is as shown in Fig.7, commonly referred to as a 'series – parallel' arrangement because a number of coils are connected in series to form a group and the groups in turn are connected in parallel.

Note that it is also possible to connect the coils together in simple parallel which will allow the highest possible current at the lowest possible voltage, exactly opposite to the original windings.

The choice of exactly how many coils to connect in parallel groups is largely determined by the application and by experience in operation – in fact you may notice that Fisher and Paykel themselves have made many modifications to their motor since it first came out.

For my application, the motor produced good power and speed and hummed along under load without any overheating.

The best advice I can offer is to get a hold of a good book on magnetism and motors (SILICON CHIP sells a couple of good ones) and put in some motor operating hours.

The complete system is shown on the test bench in Fig.8a, with the driver box connected to the coil windings and the Hall Effect sensors. At left, near the spline, is a roller bearing in a pressed metal housing which unfortunately didn't sit flush on its mounting flange and so needed three little bobbins as standoffs.

By the time you're reading this, I will hopefully have machined off the spline and mounted a small pulley to drive a 'V' or cog belt. SC

Light-level rivals halogens – at MUCH less power!

# 10W LED Floodlight

Design by Branko Justic* Words by Ross Tester

*LEDs have come a long, long way in recent times. Who would have thought that you could have a LED floodlight with brightness which rivals that that of incandescent lamps of yesterday? This compact LED floodlight is efficient, simple to build and cheap!*

**When the Australian government** announced its ban on incandescent lamps in 2007, one of our first thoughts was "what are we going to do for floodlights?".

Mainly powered by halogen lamps of 150 and 500W ratings, these floodlights have become incredibly popular in domestic, industrial and public lighting installations.

Until quite recently, there simply wasn't a viable alternative to the halogen lamp, often called a QI lamp, which stands for Quartz Iodine (the construction and gas inside), not Quite Interesting (the TV show).

But with the recent spectacular developments in LEDs, there is now a very effective replacement for power-hungry halogen lamps.

To get this into perspective, halogen floodlights comparable in size to this LED floodlight generally use 150W lamps; 15 times the power! Their light output varies depending on type but a typical figure is about 2300 Lumens, or about 15 lumens per watt (2300/150). And that really only happens with a new lamp as light output drops with age.

The light output from this LED floodlight output is not as high, at 720 Lumens and therefore, 72 lumens per watt.

OK, so that's about one third the light output of the Halogen but almost five times as efficient.

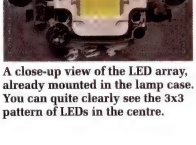
But as we show in our measurements, even those figures can be quite deceiving! (See the panel "How Bright?").

## LED array

The majority of high-power LEDs these days are made from a number of individual LEDs forming an "array". In this case, it's a 3x3 matrix of pure white LEDs, each one rated at 1.2W. The net result is a single LED light source rated at roughly 10W (there are some losses).

The array itself measures about 1cm square but with mounting, the whole assembly measures about 2cm square – still pretty small compared to a halogen lamp. Attached to each side are tabs for soldering power leads.

The good news is that in this kit, the LED array is already fitted to the lamp housing (which acts as a heatsink) and a reflector drops into place around the LED array. So the hardware side is easy!



**A close-up view of the LED array, already mounted in the lamp case. You can quite clearly see the 3x3 pattern of LEDs in the centre.**

## Driver circuit

The downside of a LED, especially an ultra-high-brightness type, is that you cannot simply connect power to it. LEDs need to be "driven" by an appropriate supply or they will be burnt out very quickly.

With low-power LEDs, it's easy; a suitable current-limiting resistor will do the job. But high-power LEDs need a driver circuit to suit the type of LED/number of LEDs. And this project has the answer

to this question as well: a tiny (30 x 23mm) PCB which contains the constant current driver circuit.

It's a simple circuit but perfectly adequate for the purpose. Many (probably most) high-power LED drivers use a switch-mode driver but they are more complicated and usually generate some (and some a LOT!) radio-frequency interference, which must be suppressed.

This two-transistor circuit shown in Fig.1 doesn't have this drawback yet still manages about 80% efficiency, when used with a 12V source. It has only two connections, power in and power out and it can be connected in series with the positive or negative side of the LED array.

Ideally though, it should be in the negative side (ie, between the LED array and the negative supply) because that way the collector of the main regulator transistor (a TIP42C) will not need to be insulated from the lamp housing (the collector and the lamp housing will both be at the negative potential).

## How it works

As mentioned, the TIP42C is the current control transistor, biased on by a BC327. It works in the following way: the base-emitter junction of the BC327 effectively monitors the voltage developed across the two 1.2Ω resistors connected in parallel. These act as a sensing resistor for the current passed by the TIP42C and therefore, the LED array.

Since the two resistors in parallel give an effective resistance of 0.6Ω and the base-emitter junction of the BC327 has a nominal voltage across it of 0.6V, this sets the emitter current of Q1 to 1A – exactly what we want for this array.

You may ask why there are two 100Ω resistors connected in series with the collector of the BC327. There is no magic in this; these two values provide sufficient base current for the TIP42C under all voltage conditions to which it is likely to be connected.

You may also wonder why we are presenting an analog regulator when, in this very same issue, we are presenting a highly efficient switching regulator, the MiniSwitcher. In that article, Nicholas Vinen has poured scorn on analog regulators.

**The photo doesn't really do it justice: it's so bright, it's dazzling!**

But the MiniSwitcher is a voltage regulator and we need a current regulator for this application. The analog current regulator has several advantages; cheaper, smaller and simpler. And in any case, we are not too worried about efficiency which, as already noted, is above 80%.

That means that it will dissipate between 2 and 3W but

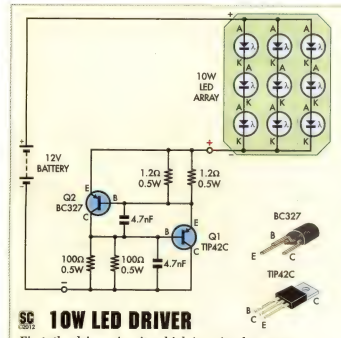



**Fig.1: the driver circuit, which is a simple constant-current regulator, drives the 3 x 3 LED array with a current of about 1A.**

## Parts list – 10W LED Floodlight

1 Hardware Pack, consisting of lamp housing, gland, cable and pre-mounted 3 x 3 LED array
1 PCB, coded K318, 30 x 23mm
1 two-way screw terminal block, PCB mounting
1 TIP42C PNP power transistor (Q1)
1 BC327 PNP transistor (Q2)
2 4.7nF ceramic capacitors
2 100Ω 0.5W resistors
2 1.2Ω 0.5W resistors
1 length 2-core insulated power cable (length to suit)
1 M3 x 10-15mm screw with nut and washer.

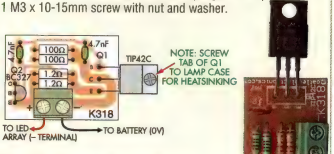



**Fig.2: PCB component overlay with a same-size photograph at right.**

**In this and the photo at right, we've disassembled the lamp housing to show how it all goes together. The reflector "drops into" the space above the LED array – but be careful that it doesn't short the two solder connections (on each side of the array). If there is any doubt, we'd be inclined to put a washer or two under the reflector where the screws hold it in place.**

**This photo shows the disassembled lamp housing from the rear. Note that in this shot, neither the holes for the PCB mounting screw nor the cable gland have been drilled (the cable gland hole can be seen in the pic at left). The blue item second from front is the reflector, again seen in the photo at left. Don't be tempted to leave out the gaskets – they keep the whole thing waterproof when used outside.**

that is not an issue since we have a good heatsink available in the form of the lamp housing; fastening the TIP42C to the case will provide the cooling required.

Some current regulators of this configuration can be prone to oscillation, so 4.7nF capacitors are included between the collectors and bases of both transistors; as they say in Ireland, to be sure, to be sure.

## Construction

The PCB component overlay clearly identifies the location and where appropriate, the orientation of polarised components. Of the latter, there are only two, the transistors and of these only one might cause any confusion at all.

This is the TIP42C power transistor, which must be soldered into the board with maximum length of legs emerging, then folded down 90° so that it can be screwed to the case/heatsink. It should be obvious which way around it goes, even if you don't identify the legs: when laid flat, its metal tab should be in direct contact with the case.

The other (smaller) transistor is soldered in so its orientation matches the overlay on the PCB.

Leave the PCB-mounting terminal block until last, if only because it's big. Solder this in so that the lead access is to the edge of the PCB.

## The LED array

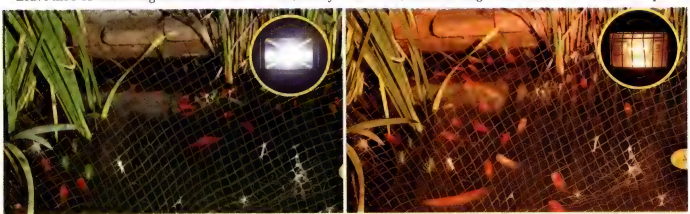
As noted earlier, this should be supplied already mounted in its heatsink (complete with heatsink compound), with two terminals ready for soldering the power leads onto. The + and - terminals are clearly marked, though may not be immediately obvious in some light. Ensure that you get them correct and you don't make the joins too high.

## PCB mounting

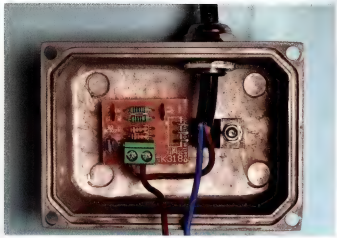
As mentioned earlier, the driver PCB can be mounted between the +12V (power) terminal and the LED array or between the LED array and the 0V power terminal.

Because the tab of the power transistor (collector) is connected to 0V anyway, it makes sense to mount it in the negative line. Therefore the case itself will be at 0V and no insulating washer will be needed between the collector and the case.

Obviously, if you do want to mount the PCB in the positive line, an insulating washer and bush WILL be required



**A comparison between the 10W LED floodlight featured here and a typical mains floodlight fitted with a 150W QI lamp. These unretouched photos of my fishpond (ignore spiders on bird net!) were shot within moments of each other late at night, at the same speed and aperture (2sec, f4.0), with lamps in the same spot. Inset top right are the images of the two floods. Voltage on the LED was 12.4V while the mains voltage on the QI was 237V. Incidentally, the QI attracted many more fish than the LED!**



**The PCB mounts in the "bottom" of the rear of the lamp housing by means of a single screw and nut through the tab on the power transistor. There is an insulating washer in this photo – this is only necessary if you want to mount the driver PCB between +12V and the LED array. Place some dollops of neutral-cure silicone sealant underneath the PCB to prevent any short-circuits to the case.**

**And here it is completely assembled and ready for use. It's close to the same size as a 150W halogen floodlight but has the advantage of using much less power. Another big advantage over halogen lamps is that LEDs aren't fussed which way you angle them (halogen lamps need to operate very close to horizontal for longest life). The bracket on the rear can be rotated to suit any mounting position.**

if you want to avoid having the case at +12V.

Our photo shows how the PCB is mounted flat in the rear portion of the case. A single 3mm screw and nut through the power transistor tab is all that is necessary to hold the board in place (there are no mounting holes on the PCB itself). The hole for this screw will need to be drilled in the case but position is not overly important (as long as the PCB fits!). To prevent the bottom of the PCB shorting to the case, place a few dollops of neutral-cure silicone sealant underneath the PCB.

A waterproof cable gland (which also requires a hole drilled through the case) secures the 12V power cable. In early Oatley kits, you may be supplied a length of 3-core mains flex but 2-core (red and black) flex would be preferable – you never know when someone, sometime, somewhere might accidentally connect mains flex to 230V.

If you do use 3-core cable, the green/yellow is not used; the brown lead is used as the +12V lead and the blue becomes the 0V. Remove about 150mm of outer insulation from the cable and cut off (but retain!) all but about 40mm of the red*(brown)* wire. Bare about 5mm of wire from both the red(brown) and black*(blue)*, pass the cable through the gland so there is about 15mm or so of outer insulation inside the gland.

Connect the short red*(brown)* wire to the + terminal on the PCB.

There are two holes already drilled in the lamp case which line up pretty well with the two terminals on the LED array. Pass the black*(blue)* wire through the hole which lines up with the – terminal on the LED array and carefully solder it on. The length of red*(brown)* wire which you previously removed goes through the other hole and solders to the + terminal on the LED array. Make sure there are no stray strands of wire which can short to the case.

The other end of this red*(brown)* wire connects to the – terminal on the PCB. That's right, the "–" terminal. All you need do is connect to a 12V power source, preferably with a switch to turn on and off.

And that's it: the lamp housing comes with a rotatable bracket if you wish to mount the LED Floodlight permanently. With a rather modest current draw of just over 1A, a solar-backed battery supply makes a lot of sense – and the amount of light you get would be rather more than other "solar" systems.

## How Bright Is It?

Halogen floodlights are popular because they are so bright; much brighter than "traditional" incandescents and streets ahead of anything fluorescent.

That might be about to change!

Late at night on a fishpond we set up two mini floodlights – the one described here and a standard 150W halogen. These luminaires are roughly the same physical size, hence the choice.

The first observation was just how yellow the halogen was in comparision to the LED – and we had always thought that the halogen lamps gave a nice, white light, especially compared to standard incandescents (see photos opposite for comparison).

But the second observation really surprised us. Using our Nikon DSLR as a light meter, we measured the output from both at the same distance and axis. To ensure accuracy of reading, we set the speed to 1/1000s and filled the frame with the floodlight from a distance of 2m.

Guess what! The in-camera meter read *exactly the same* with both floodlights. That's to within plus and minus half a stop.

Given the fact that the LED floodlight draws 10W and the halogen 150W, that's a pretty powerful message!

Finally, after about 15 minutes (the time it took us to make the measurements), the LED Floodlight was warm, but not uncomfortably so. The halogen floodlight? Anyone got any eggs to fry?

## Where from, how much?

This kit comes from Oatley Electronics who hold the copyright on the PCB design. A complete kit of parts which includes all those components listed in the parts list is available from Oatley Electronics for $29.00 + $7.00 P&P.

Contact Oatley Electronics on (02) 9584 3561, via email (**sales@oatleyelectronics.com**) or via their website (**www.oatleyelectronics.com**).

* Branko Justic is manager of Oatley Electronics.

# Crystal DAC

## For the very best performance from 24-bit/96kHz recordings – uses the Crystal CS4398 DAC and a discrete transistor output stage

**This new DAC board can be substituted for the original board used in our Hifi Stereo DAC project (Sept-Nov 09) without any major changes, effectively replacing the Burr-Brown DSD1796 DAC IC with the high-end Cirrus Crystal CS4398. Its harmonic and intermodulation distortion figures are significantly lower than before although some people will have difficulty discerning the differences. Try it and find out for yourself.**

THE INSPIRATION for this project came from our review of the Marantz CD6003 CD player, which appeared in the June 2011 issue. At the time, we made some measurements using our Audio Precision System One and discovered that it not only had a very low harmonic distortion figure for a CD player but it was practically flat across the audible frequency band (20Hz-20kHz).

We figured that this was partly due to its Crystal (Cirrus Logic) CS4398 DAC (digital-to-analog converter) IC. This is mounted on a large PCB, amongst a forest of discrete and passive components. So we thought, hmmm . . . could we do something similar for our DAC design? We suspected they were also doing some fancy digital processing using a DSP (digital signal processor) to get that level of performance but that the CS4398 DAC must also be pretty good for such an excellent result.

It turns out we were right on both counts. The CS4398 is very good but Marantz seem to be doing some digital interpolation (possibly increasing the sampling rate to 96kHz or 192kHz) to keep the distortion so low. While our new DAC board does not have the benefit of digital interpolation, it is clearly superior to the previous design, especially when processing 24-bit/96kHz program material.

If you have already built a Stereo DAC kit and would like to try out this new board, it's pretty easy. You just build the new PCB and swap it for the old one; it's the same size and the critical parts are in the same locations. You then reprogram or swap the microcontroller on the input board and Bob's your uncle.

Like the Marantz, we designed the filtering hardware using all discrete components (ie, bipolar transistors and passives).

There was some controversy on the internet (unheard of!) over our choice of op amps in the original DAC design (SILICON CHIP, September, October & November 2009). This time we have avoided using those "evil" little black boxes, which should make the extreme audiophile cognoscenti happy (impossible!).

The resulting circuit has a lot more components than it would if we had used op amps but they are all cheap and commonly available. The resulting wide bandwidth compared to an op amp means that the output filtering works very well.

## Performance

We tested both the original and new DAC designs extensively, using both our Audio Precision System One and the newer Audio Precision APx525 with digital processing. We also performed numerous listening tests, including blind A/B tests.

The first result that became clear from all this testing is that the original design really is very good. Its distortion and noise are low (including intermodulation distortion), its linearity is very good and it generally sounds excellent. However, the new DAC design measures even better, with lower distortion (especially at high frequencies), even lower intermodulation distortion and astounding linearity down to -100dB.

Fig.1 shows a comparison of the harmonic distortion between both channels of the original and the new DAC design. These tests were performed on the same unit with just the DAC boards swapped, so they give an apples-to-apples comparison.

Note that noise has been digitally filtered out of this measurement completely, for a couple of reasons. First, both DACs have quite a bit of high-frequency switching noise in their output (but a lot less than some DVD and Blu-ray players we've tested!) and this can mask the distortion if we set the bandwidth wide enough to capture harmonics of high audio frequencies. Second, the 20Hz-20kHz residual noise of both the original and new boards is similar and this too means that a THD+N comparison would tend to understate the reduction in harmonic distortion obtained with the newer design.

As you can see, harmonic distortion with the CS4398 is substantially lower than the original design, both at high frequencies (above 3kHz) and low frequencies (below 100Hz). The differences between channels are due to asymmetries in the PCB layout as well as mismatches between the two channels within the DAC ICs themselves (eg, due to resistor ladder tolerances).

Fig.2 shows the channel separation for both units. The lines labelled "left" show how much signal from the right channel couples into the left and the lines labelled "right" show the opposite. In both cases, channel separation is very good and is generally better than -100dB across the audio spectrum. The older design is slightly better in this respect, although the difference is largely academic.

Fig.3 compares the linearity of both DACs. This plot shows the deviation

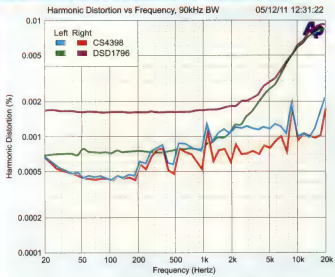



**Fig.1: harmonic distortion (ignoring noise) versus frequency for the original (DSD1796-based) and new (Crystal CS4398-based) DACs. The newer design has lower distortion overall but especially above 2kHz. The channels differ slightly due to layout asymmetries and differences in the ICs themselves. The spikes at 1.2kHz and 9kHz are due to aliasing between the test and sampling frequencies.**

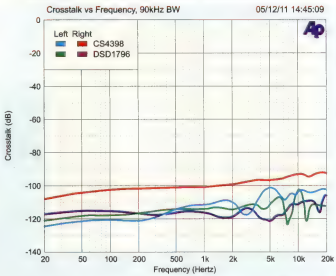



**Fig.2: a comparison of channel separation (ie, crosstalk) for the original and new DAC boards. The original is slightly superior but both are very good, with less than -93dB crosstalk at any frequency and separation of at least 100dB up to 1kHz. As is typical, there's more coupling in one direction (for the new design, left channel to right channel) than the other, again mainly due to asymmetry.**

between the expected and actual output level for a sinewave at a range of levels between -60dB and -100dB. Both DACs perform extremely well in this test but the CS4398 is especially good, with a maximum deviation of no more than 0.25dB at -100dB! Its deviation is essentially zero above -84dB while the DSD1796 still shows some deviation up to -70dB.

Note that all of the above test results were obtained with the Audio Precision APx525 (which can test in the analog or digital domain) using 24-bit 96kHz signals fed into a TOSLINK input of the Stereo DAC project.

Fig.4 shows the FFT frequency spectra for the updated DAC with one channel in magenta and the other in khaki. This was computed with a one million sample window, an equi-ripple algorithm and 8x averaging. The test signal is at 1kHz and the bandwidth is 90kHz. The harmonics of the test signal are clearly visible at 2kHz, 3kHz, etc. Also visible is some 50Hz and 100Hz mains hum at around -120dB, as well as various intermodulation products of this hum with the fundamental and its harmonics.

As we said earlier, both DACs are very good but the updated design generally has better figures. We also ran the SMTPE intermodulation distortion test on both. This involves sending a 4:1 mix of 7kHz/400Hz sinewaves to the test device. These frequencies are then filtered from its output (400Hz with a high-pass filter and 7kHz with a notch filter) and the remaining harmonics measured. These will generally be the sum and difference frequencies of 6.6kHz and 7.4kHz but possibly other harmonics too.

The old design gives an intermodulation distortion level of around 0.0018% (-95dB) while the new design gives 0.0006% (-105dB); a significant improvement.

## Listening tests

The results of our listening tests were somewhat controversial. We used our 20W Stereo Class A Amplifier (May-September 2007) and the M6 Bass Reflex Loudspeakers (November 2006), while the 3-Input Selector presented last month was used to switch between the original and updated Stereo DAC prototypes. The original prototype was set to a volume of -0.5dB and the levels matched almost perfectly, giving seamless switching between the two.

The two Stereo DACs themselves were fed with digital audio from a Blu-ray player with separate TOSLINK and S/PDIF outputs.

Some staff members could not tell the difference in sound quality between the two DACs while others claimed to be able to hear a distinct difference between the two on certain passages, although the difference was not obvious on other passages. With complex choral music, two of the "guinea pigs" were able to pick the updated DAC as sounding "brighter". On other types of music, a difference could be discerned but we could not reliably pick which DAC we were listening to.

You'll have to make your own mind up about whether the new design gives an audible improvement. However, we can be certain that this upgraded DAC design gives far superior performance compared to virtually any CD, SACD, DVD or Blu-ray player on the market. And for those people who think that Blu-ray players are generally superior in terms of sound quality, our limited tests demonstrated that this is not necessarily true. Cheap Blu-ray players are just that – cheap!

## Circuit description

Fig.5 shows the circuit diagram for the new board. IC1 is the CS4398 DAC chip and this is wired to 16-pin IDC socket CON1. Its configuration is identical to that of the original DAC board, carrying the 3.3V supply from the control board as well as audio data (pins 4, 6, 8 & 10) and serial control

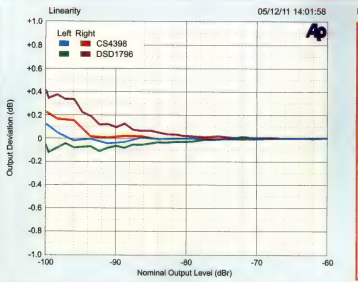



**Fig.3: a comparison of the linearity of the original and updated DAC boards. Delta-Sigma DACs typically have good linearity and in fact both are excellent. However, the updated board (with the CS4398) is the best of the two with an astounding deviation of less than one quarter of a decibel at levels down to -100dB! (The dynamic range of CD-quality audio is just 96dB).**

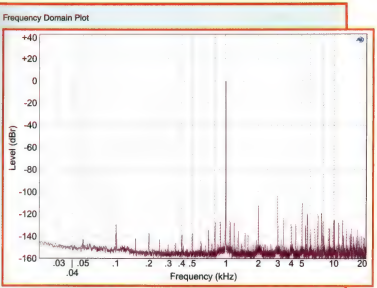



**Fig.4: a frequency domain plot (ie, spectrum analysis) of the output of the updated DAC for a 1kHz sinewave. Eight FFTs were averaged to reduce noise. The harmonics are clearly visible at multiples of the fundamental (2kHz, 3kHz, etc) as well as mains hum at 100Hz. You can also see the various intermodulation products of the fundamental and its harmonics with 100Hz.**

data (pins 7, 9, 11 & 13). There are also two mute feedback lines (pins 15 & 16), allowing the micro to sense output silence.

IC1 has a dual 3.3V and 5V power supply with multiple supply pins for each internal section. Both rails have 100µF bulk bypass capacitors. Each supply pin also has a 100nF bypass capacitor for lower supply impedance at higher frequencies (>100kHz).

VLS (pin 27) is supplied 3.3V to suit the audio serial data levels while VLC (pin 14) is at 5V to match the microcontroller's I/O levels. To avoid switching noise feeding back into the 5V rail, which also powers analog circuitry, a 100Ω stopper resistor is included.

VD (pin 7) is the supply pin for the DAC's digital core (digital filtering and so on). This runs off 3.3V while the internal analog circuitry (op amps, etc) runs off a 5V rail connected to VA (pin 22). This 5V rail is also fed separately to VREF (pin 17) for the DAC reference voltage. Capacitors at FILT+ (pin 15) and VQ (pin 26) smooth IC1's internal reference voltages.

VQ is the quiescent output voltage and generally sits at half supply (ie, 2.5V). We aren't using the DSD (Direct Stream Digital) input pins on the IC so they are tied to ground.

The microcontroller's serial I/O pins connect to header CON1 via LK1-LK4. These are closely-spaced pads on the bottom of the PCB which can be bridged with solder. The CS4398 can operate without a microcontroller and to do so, pins 9-12 are connected to either ground or VLC (+5V).

This arrangement allows those pins to be connected to configure the DAC correctly, even in the absence of a microcontroller. However, if this is done, many features of this design do not operate properly, such as volume control, automatic input scanning and muting. As a result, we suggest that constructors simply bridge LK1-LK4 and reprogram the micro with the new software. All the features of the original design will then work normally.

## Analog filtering

The DAC IC we used previously (Burr Brown DSD1796) has differential current outputs while the CS4398 has differential voltage outputs. That means we no longer need current-to-voltage converters; they are internal to IC1. However, we still need to filter the outputs to remove the DAC switching noise and convert the differential (balanced) signals to unbalanced, to suit the inputs of a typical amplifier.

We have used the recommended filter, a 2-pole Butterworth low-pass arrangement, consisting of six resistors and five capacitors for each channel. These are shown just to the right of IC1.

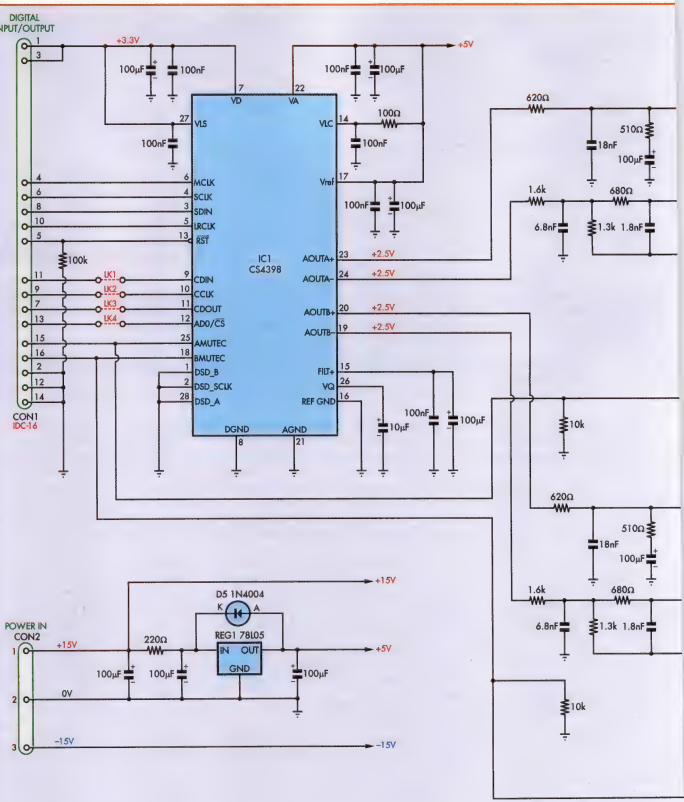
The operation of this filter is quite complicated since the two RC filters for each channel interact with each other. Let's look at the left channel; the right channel circuit is identical. The non-inverted output from IC1 comes from pin 23 (AOUTA+) and the inverted signal from pin 24 (AOUTA-).

The waveforms from each pin are (theoretically) identical but opposite in polarity, ie, one swings up when the other swings down and vice versa. Both signals are attenuated, with a gain of around 0.45, by a pair of resistive dividers. While the division ratios are very similar, the actual resistor values differ: 620Ω/510Ω for the non-inverted signal and 1.6kΩ/1.3kΩ for the inverted signal.

These resistors also form single-pole, low-pass filters in combination with the 18nF (non-inverted signal) and 6.8nF (inverted signal) capacitors. The attenuating resistors are effectively in parallel with each other, for a -3dB point of around 32kHz in both cases.

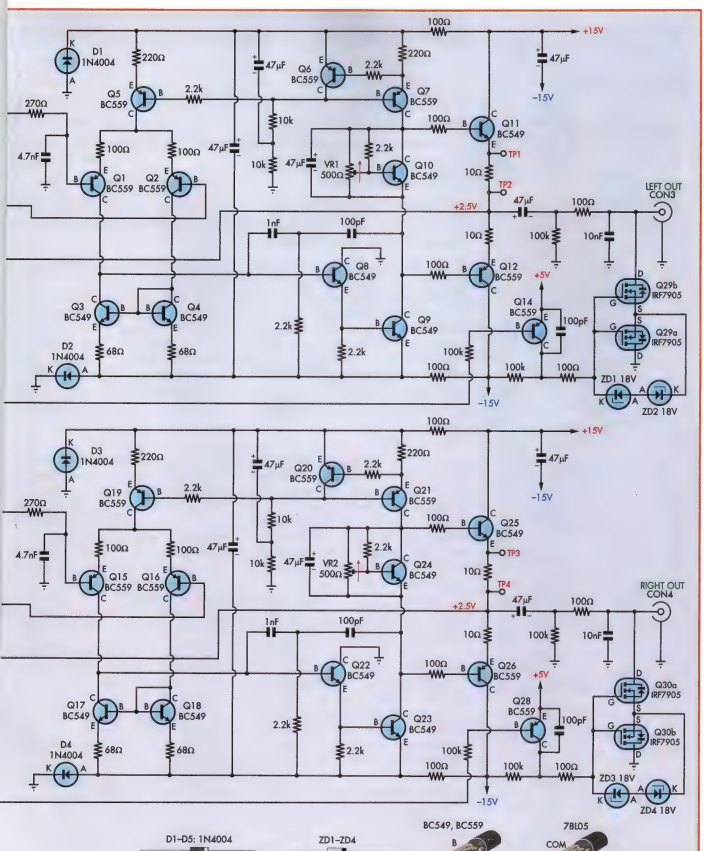
These are then followed by another set of RC low-pass filters – 270Ω/4.7nF for the non-inverted signal and 680Ω/1.8nF for the inverted signal. In isolation, these have corner frequencies of around 130kHz.

Note that the bottom ends of the




## STEREO CRYSTAL DIGITAL-TO-ANALOG CONVERTER

**Fig.5: the circuit is based on a Cirrus Logic (Crystal) CS4398 stereo DAC chip (IC1). This has differential outputs (pins 23 & 24 and 20 & 19) and these drive discrete audio output stages based on transistors Q1-Q12 in the left channel and Q15-Q26 in the right channel. Q14, Q15 & dual N-channel Mosfets Q29a-b & Q30a-b mute the outputs when there is no signal from the DAC. Power comes from an external ±15V supply, with REG1 providing a +5V rail for IC1.**


D1 1N4004
220Ω
Q5 BC559
2.2k
270Ω
4.7nF
100Ω
100Ω
Q1 BC559
Q2 BC559
47µF
10k
47µF
Q6 BC559
2.2k
220Ω
Q7 BC559
100Ω
+15V
47µF
−15V
Q11 BC549
TP1
10Ω
VR1 500Ω
2.2k
Q10 BC549
TP2
+2.5V
47µF
100Ω
LEFT OUT CON3
1nF
100pF
10Ω
100k
10nF
Q8 BC549
Q12 BC559
+5V
Q14 BC559
100pF
Q29b IRF7905
Q29a IRF7905
Q3 BC549
Q4 BC549
2.2k
Q9 BC549
2.2k
D2 1N4004
68Ω
68Ω
100k
100Ω
ZD1 18V
ZD2 18V
−15V
D3 1N4004
220Ω
Q19 BC559
2.2k
270Ω
4.7nF
100Ω
100Ω
Q15 BC559
Q16 BC559
47µF
10k
47µF
Q20 BC559
2.2k
220Ω
Q21 BC559
100Ω
+15V
47µF
−15V
Q25 BC549
TP3
10Ω
VR2 500Ω
2.2k
Q24 BC549
TP4
+2.5V
47µF
100Ω
RIGHT OUT CON4
1nF
100pF
10Ω
100k
10nF
Q22 BC549
Q26 BC559
+5V
Q28 BC559
100pF
Q30a IRF7905
Q30b IRF7905
Q17 BC549
Q18 BC549
2.2k
Q23 BC549
2.2k
D4 1N4004
68Ω
68Ω
100k
100Ω
ZD3 18V
ZD4 18V
−15V
D1–D5: 1N4004
ZD1–ZD4
BC549, BC559
B
E
C
78L05
COM
IN
OUT

# Silicon Chip Binders

These binders will protect your copies of SILICON CHIP. They feature heavy-board covers & are made from a distinctive 2-tone green vinyl. They hold 12 issues & will look great on your bookshelf.

★ 80mm internal width

★ SILICON CHIP logo printed in gold-coloured lettering on spine & cover

★ Buy five and get them postage free!

**Price: $A14.95 plus $A10.00 p&p per order. Available only in Aust.**

**Silicon Chip Publications**
**PO Box 139**
**Collaroy Beach 2097**

Or call (02) 9939 3295; or fax (02) 9939 2648 & quote your credit card number.

**Use this handy form**

Enclosed is my cheque/money order for

$_____ or please debit my

❑ Visa ❑ Mastercard

Card No:

_____

Card Expiry Date ____/____

Signature _____

Name _____

Address _____

_____ P/code_____


## Features & Specifications

| | |
|---|---|
| Output Level | 1.9V RMS |
| Signal-To-Noise Ratio | -112dB |
| Idle Channel Noise | <-124dB |
| Channel Separation | ~100dB @ 10kHz (see Fig.2) |
| Harmonic Distortion (see Fig.1) | <0.001% @ 1kHz, <0.002% 20Hz-20kHz |
| THD+N | 0.0014% @ 1kHz |
| Intermodulation Distortion | <0.001% (400Hz/7kHz 4:1) |
| Frequency Response | -0.25,+0.05dB 20Hz-20kHz |
| Supported Sampling Rates | 32kHz, 44.1kHz, 48kHz, 88.2kHz, 96kHz |

1.3kΩ resistor and 1.8nF capacitor are connected to the output of the following differential amplifier, rather than ground. Because the output is out of phase with the inverted signal from pin 24 of IC1, this acts like a virtual ground. So there is twice the voltage across these compared to the non-inverted signal filter, hence the higher resistance values (keeping the current from each output approximately equal).

The overall filter response (determined by simulation) is -3dB at 45kHz, which is above the 30kHz or so you would expect if the filters operated in isolation. This is partly due to their interaction and also partly due to the connection from the differential amplifier's output to the inverting signal filter. As we said earlier, it's complicated!

The resulting response is -0.1dB at 20kHz. Including the DAC's internal filtering and the additional filtering at the output, the overall response for the circuit is -0.25dB at 20kHz, which is quite acceptable.

The active filter gives around 13dB of attenuation at 100kHz, increasing at around 12dB/decade. This is ultimately limited by the bandwidth of the differential amplifier circuit and so the filter is ineffective at very high frequencies (many MHz).

This means that the 1.8nF capacitor in the filter network can couple very high frequencies through to the output but their level is too low to cause problems.

### Discrete op amps

As noted above, we have used discrete transistors in this circuit instead of op amp ICs. The design is very similar to that used in the Hifi Stereo Headphone Amplifier (October-November 2011).

Again referring to the left channel only, the base of NPN transistor Q1 is the non-inverting input of the differential amplifier while the base of Q2 is the inverting input. Both transistors have 100Ω emitter degeneration resistors to improve linearity.

PNP transistor Q5 acts as a constant current source for the long-tailed pair and this is set to around 3mA by a 220Ω resistor. NPN transistors Q3 and Q4 form a current mirror collector load, with 68Ω emitter resistors to improve current sharing.

The current into the base of NPN transistor Q8 is proportional to the difference in voltage between the two inputs (ie, between the bases of Q1 & Q2). Q8 and NPN transistor Q9 act as a beta-enhanced transistor (like a Darlington) and operate as a common-emitter amplifier. PNP transistor Q7 acts as a constant-current collector load at around 3mA.

Together, Q8 & Q9 form a transimpedance amplifier, converting the current delivered to the base of Q8 into a voltage at Q9's collector. This voltage controls the output stage which consists of NPN transistor Q11 and PNP transistor Q12 in a push-pull, emitter-follower configuration.

NPN transistor Q10 forms a $V_{BE}$ multiplier. This generates an adjustable bias (set by trimpot VR1), so that both Q11 & Q12 are conducting full time, giving Class A operation.

The 100pF and 1nF capacitors between Q9's collector and Q8's base provide frequency compensation. The two constant current sources (Q5 & Q7) limit their charge and discharge currents and so set an upper limit on slew rate and frequency, reducing gain at

very high frequencies below the level required for sustained oscillation.

With this 2-pole compensation scheme, the 2.2kΩ resistor to the -15V rail increases the open loop gain available at higher audio frequencies (see "A Look At Amplifier Stability & Compensation", July 2011). At low frequencies, this resistor shunts much of the current passing through the 100pF capacitor so that it never reaches Q8's base but at much higher frequencies, the capacitor's impedance so low that it has no effect.

PNP transistor Q6 provides the bias and negative feedback for current sources Q5 and Q7, keeping the voltage across their emitter resistors constant. Its own collector load is a bootstrapped constant-current sink formed from two 10kΩ resistors and a 47µF capacitor. This prevents variations in the supply rail from affecting the current regulation, as this would increase inter-channel crosstalk and reduce supply hum rejection.

The signal output appears at the junction of the 10Ω emitter resistors for Q11 & Q12. The output voltage has a 2.5V DC offset which is removed by a 47µF DC-blocking capacitor with a 100kΩ bias resistor. The audio signal then passes through an additional RC low-pass filter (100Ω/10nF) before passing to the output RCA connector CON3 (CON4 in the right channel).

Since the output signal swing is about ±2.7V (1.9V RMS), the 100Ω resistor limits the short-circuit output current to 27mA. Otherwise, Q11 or Q12 would quickly burn out with a shorted output.

## Muting

As suggested in the CS4398 data sheet, we have added muting circuitry to the outputs. This consists of a dual Mosfet for each channel, the Mosfets operating as analog switches. These short the output to ground when there is no signal from the DAC.

This suppresses any clicks or pops that may occur when the sample rate changes or the DAC selects a different input and so on. It also makes the signal-to-noise ratio appear to be better, by reducing the idle channel noise. But it doesn't affect the actual signal-to-noise ratio during playback since the muting Mosfets are then switched off.

These components are not strictly necessary but don't add much cost or complexity to the circuit.

The example circuit in the CS4398 data sheet uses 2SC2878 NPN transistors rather than Mosfets. These are a special type of bipolar transistor with an unusually high reverse $h_{FE}$ of 150, compared to around 1-2 for a normal NPN transistor. So they can operate normally even with their collector and emitter reversed; in this case, when the collector voltage (ie, signal) swings below ground.

2SC2878 transistors are available but not widely so. By contrast, the dual Mosfets we have used instead can be bought from many different sources.

The CS4398 DAC automatically determines the polarity of its AMUTEC and BMUTEC outputs (for the left and right channels, respectively) based on the external biasing arrangement. In this case, they have a resistive path to ground and so the chip drives them low to mute and high otherwise.

When the mute output is low, current is sunk from the base of PNP transistor Q14 via the 100kΩ resistor, turning it on. Q14 then pulls the gates of Q29a & Q29b high to 5V via a 100Ω resistor. The 100Ω resistor creates a low-pass filter with the Mosfet gate capacitance, preventing voltage spikes due to stray inductance.

The two Mosfets in each pair are connected source-to-source, with one drain connected to the output and the other to ground. As a result, the two parasitic body diodes are connected anode-to-anode so that regardless of the output signal voltage polarity, at least one is reverse-biased. If we had used a single Mosfet instead, the signal would be clipped to within one diode drop to ground when the body diode was forward-biased.

These diodes also clamp the sources of both Mosfets to no more than 1V above ground. So when the gates are at +5V, both Mosfets have a gate-source voltage of at least +4V. The on-threshold for the IRF7905 is no more than 2.25V so they are turned on hard in this situation, shorting the output to ground.

When the AMUTEC mute output goes high, Q14 turns off and so the gates of Q29a & Q29b are pulled to -15V via a 100kΩ resistor. This is well below the lowest output signal voltage of -2.7V and so both Mosfets switch off and the signal is unaffected.

When off, the Mosfets do have some capacitance, due mainly to the

## Parts List

1 PCB, code 01102121, 94 x 110mm
1 16-pin PCB-mount vertical IDC connector (CON1)
1 3-way mini PCB-mount terminal block, 5.08mm pitch (CON2)
1 white PCB-mount switched RCA socket (CON3)
1 red PCB-mount switched RCA socket (CON4)
2 500Ω mini sealed horizontal trimpots
M3 nuts and flat washers (may be required to adjust new PCB height to suit holes in existing case)

**Semiconductors**

1 CS4398 Stereo DAC IC (IC1) (Element14 1023397)
1 ATMega48 programmed with 0110212A.hex (or reprogram existing micro)
2 IRF7905 dual N-channel SMD Mosfets (Q29,Q30) (Element14 1791580)
1 78L05 5V linear regulator (REG1)
14 BC559 PNP transistors (Q1-Q2, Q5-Q7, Q12, Q14-Q16, Q19-Q21, Q26, Q28)
12 BC549 NPN transistors (Q3-Q4, Q8-Q11, Q17-Q18, Q22-Q25)
5 1N4004 1A diodes (D1-D5)
4 18V zener diodes, 0.4W or 1W (ZD1-ZD4)

**Capacitors**

9 100µF 16V electrolytic
10 47µF 35V/50V electrolytic
1 10µF 16V electrolytic
6 100nF MKT
2 18nF MKT
2 10nF MKT
2 6.8nF MKT
2 4.7nF MKT
2 1.8nF MKT
2 1nF MKT
4 100pF NP0/C0G

**Resistors** (0.25W, 1%)

| | |
|---|---|
| 7 100kΩ | 2 510Ω |
| 6 10kΩ | 2 270Ω |
| 10 2.2kΩ | 5 220Ω |
| 2 1.6kΩ | 17 100Ω |
| 2 1.3kΩ | 4 68Ω |
| 2 680Ω | 4 10Ω |
| 2 620Ω | |

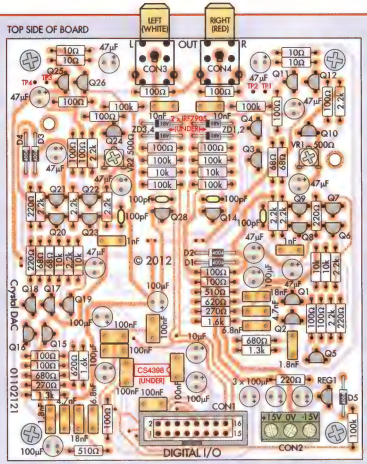
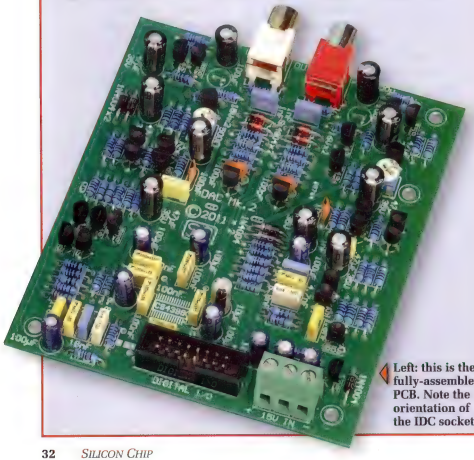



**Fig.6: follow this layout diagram to install the through-hole parts on the PCB. Take particular care with the transistors. There are two different types (BC549 & BC559) – don't get them mixed up.**



**Left: this is the fully-assembled PCB. Note the orientation of the IDC socket.**

drain-source capacitance which is at a maximum of about 350pF when the drain-source voltage is zero. However, most of the time, the two capacitances are in series and so there is effectively no more than 200pF additional capacitance at each output. This is swamped by the parallel 10nF capacitors and so has no effect on distortion.

A pair of back-to-back 18V zener diodes between the gates and sources of each Mosfet protect them from damage in the case of a voltage spike or static discharge. Due to the low currents normally involved, the zeners will conduct below 18V, clamping the gate-source voltages below the 20V maximum rating.

The 100pF capacitor between the emitter and collector of Q12 helps keep it on when power is first applied, preventing start-up clicks or pops. Q12 is then held on by the resistors between its base and ground until the DAC IC begins actively driving the mute outputs.

## Power supply

The ±15V supply for the amplifier circuitry is provided by an external power supply board (as used in the original Stereo DAC), wired to CON2. This powers the output stages directly, while the rails feeding the input stages are applied via RC filters. These filters each comprise a 100Ω resistor in series with each rail plus a 47µF capacitor between the two rails.

This improves the channel separation by preventing supply voltage variations to the input stages due to current demands from the output stages. Diodes D1 & D2 in the left channel and D3 & D4 in the right channel prevent the 47µF capacitors from pulling either supply rail to the wrong side of ground during power-up or power-down.

The +5V supply is derived from the +15V rail using REG1. D5 prevents REG1 from being damaged if the +15V rail collapses faster than the +5V rail. The associated input and output capacitors ensure regulator stability and reduce output noise, while the 220Ω resistor reduces dissipation in REG1 and helps filter any ripple from its input supply.

## Building it

All the parts are mounted on a double-sided PCB coded 01102121 and measuring 94 x 110mm. Fig.6 shows the parts layout.

The DAC IC (IC1) should be fitted first. This device is in a 28-pin TSSOP (thin shrink small outline package) with a 0.65mm lead pitch and is installed on the underside of the PCB – see Fig.7.

That's done by first placing the PCB copper-side up, with IC1's pads to the left and right (ie, with the board rotated 90°). That done, apply a very small amount of solder to the upper-right pad with a clean soldering iron (use a medium to small conical tip).

Next, pick up the IC with tweezers and position it near the pads with the correct orientation (ie, with its pin 1 dot positioned as shown on Fig.7). That done, heat the tinned pad, slide the IC into place and remove the heat.

Now check its alignment carefully, using a magnifying glass if necessary. It should be straight, with all the pins over their respective pads and an equal amount of exposed pad on either side. If not, reheat the solder joint and gently nudge the chip in the right direction until its position is perfect.

The diagonally opposite pin should now be soldered, after which you can solder the remaining leads. Don't worry about solder bridges; they are virtually inevitable and can easily be fixed. The most important job right now is to ensure that the solder flows onto all leads and pads.

Once the soldering is complete, apply a thin smear of no-clean flux paste along the leads, then remove the excess solder using solder wick. Once the flux is heated to boiling point, this should happen quickly. Be sure to trim the end off the wick if it gets solder-logged.

You should now make a final inspection to ensure that there are no remaining solder bridges and that the solder has not "balled" onto a lead without flowing onto its pad. If there are still bridges, clean them up with more flux and solder wick.

For further information on soldering SMD packages, refer to these two articles: (1) "Soldering SMDs – It's Becoming Unavoidable", December 2010; and (2) "How To Hand-Solder Very Small SMD ICs", October 2009.

Mosfets Q29 & Q30 go in next. These are also SMDs but come in SOIC-8 (small outline integrated circuit) packages with much wider leads and greater pin spacing than the DAC chip. The leads can be soldered individually although it's a good idea to add a small amount of flux paste and use solder wick to remove excess solder when you have finished. This also helps to reflow the solder, ensuring good joints.

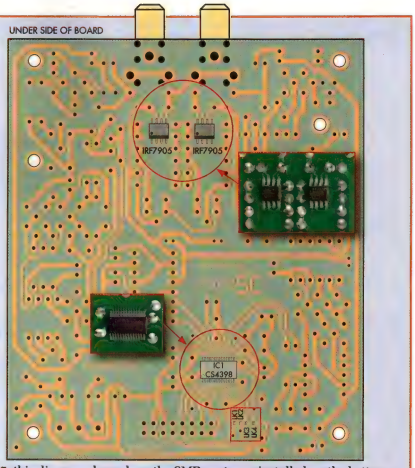



**Fig.7: this diagram shows how the SMD parts are installed on the bottom of the PCB. Note that you also have to install solder bridges for links LK1-LK4 but temporarily leave these out if you want to test the completed board without reprogramming the microcontroller – see text & panel.**

Again, be careful with the orientation. The Mosfets may not have a dot to indicate pin 1. Instead, SOIC packages normally have one bevelled edge and pin 1 is located on that side.

## Links LK1-LK4

The next step is to bridge the solder pads for LK1-LK4 (see Fig.7). This connects pins 9-12 of IC1 to CON1 and it's simply a matter of soldering across the four pairs of closely spaced pads. However, be careful not to bridge adjacent links or to bridge to the 0V and 5V pads on either side of the four links.

Note: if you want to test the board without reprogramming the microcontroller, leave these links open and connect pins 9-12 to either 0V or +5V, as detailed in the accompanying panel.

## Through-hole parts

The larger through-hole parts can now be installed, starting with the resistors, diodes D1-D5 and zener diodes ZD1-ZD4. Table 1 shows the resistor colour codes but you should also check each resistor with a DMM before installing it, as some colours can be difficult to read. It's also a bit of a hassle to remove an incorrectly-placed part from a PCB with plated through-holes.

If you do need to remove a resistor or diode, first cut the lead off one side, near the body. That done, heat the pad on the opposite side and gently pull the body until it comes away. Finally, grab the remaining lead with pliers, heat its pad and again pull it out.

Once the part is out, you can then clear the holes with a solder sucker. Other parts can be removed in similar fashion, ie, by cutting away the body and then removing the leads one at a time.

Check that each diode (and zener diode) is orientated correctly before soldering its leads. The 78L05 regulator (REG1) can then go in. Orientate it as shown and bend its leads with

## Table 1: Resistor Colour Codes

| No. | Value | 4-Band Code (1%) | 5-Band Code (1%) |
|---|---|---|---|
| 7 | 100kΩ | brown black yellow brown | brown black black orange brown |
| 6 | 10kΩ | brown black orange brown | brown black black red brown |
| 10 | 2.2kΩ | red red red brown | red red black brown brown |
| 2 | 1.6kΩ | brown blue red brown | brown blue black brown brown |
| 2 | 1.3kΩ | brown orange red brown | brown orange black brown brown |
| 2 | 680Ω | blue grey brown brown | blue grey black black brown |
| 2 | 620Ω | blue red brown brown | blue red black black brown |
| 2 | 510Ω | green brown brown brown | green brown black black brown |
| 2 | 270Ω | red violet brown brown | red violet black black brown |
| 5 | 220Ω | red red brown brown | red red black black brown |
| 17 | 100Ω | brown black brown brown | brown black black black brown |
| 4 | 68Ω | blue grey black brown | blue grey black gold brown |
| 4 | 10Ω | brown black black brown | brown black black gold brown |

pliers to match the holes on the PCB.

Now for the transistors. There are two different types, BC549 (NPN) and BC559 (PNP), so don't get them mixed up. Crank their leads so that they mate with the pads, then push them down onto the PCB as far they will comfortably go before soldering their leads.

Follow with the two horizontal trimpots, then mount the ceramic and MKT capacitors. That done, solder the electrolytic capacitors in place. These are all polarised so be sure to orientate them correctly.

That just leaves the four connectors (CON1-CON4). Make sure that the IDC socket is installed with its notch towards the edge of the PCB and that it is pushed down fully before soldering its pins. It's best to solder two diagonally opposite pins first and check that it's sitting flat before soldering the rest. Similarly, terminal block CON2 must go with its wire entry holes towards the edge of the PCB and must be flush against the board.

Be sure also to push the RCA sockets down as far as they will go before soldering their pins. The red socket is mounted on the righthand side as shown on Fig.6, while the white (or black) socket goes to the left.

### Chassis mounting

Once the assembly is complete, the PCB can be mounted in the chassis. Assuming you built you Stereo DAC from an Altronics kit, it's just a matter of removing the old DAC board and mounting the new board in its place (the mounting holes are in the same locations).

Note, however, that you may need to install some washers under the spacers to get the RCA sockets at the correct height. If so, install these between the spacers and the bottom of the case. **If you put the washers under the PCB, they could short some of the component leads to earth.**

The connectors are also in essentially the same locations, so the new PCB should slot straight in to any case that's already in use for the original Stereo DAC.

### Reprogramming the micro

You will now need to either reprogram the Atmel microcontroller on the Input PCB or replace it with a micro that has the new software. The hex file (0110212A.hex) is available for download form the SILICON CHIP website. **If you don't have an Atmel programmer, you can either purchase a programmed micro from SILICON CHIP or send yours in to have it reprogrammed for a fee (contact SILICON CHIP for details).**

### Input board modifications

There are other changes we suggest you make to the Input Board. First, the original design had 33pF capacitors between each TOSLINK receiver's output and ground. These were recommended in the data sheet for the Jaycar ZL3003 16Mbps TOSLINK receivers we used originally. However, we subsequently found that these capacitors caused some TOSLINK receivers to oscillate under no-signal conditions and published an errata in June 2010 which recommended increasing the capacitor values to 100pF.

The problem with this is that with the 100pF capacitors, the TOSLINK inputs can no longer reliably receive data with a 96kHz sample rate. As a result, we removed these capacitors altogether from our unit (there were no ill effects) and were then able to test it at 96kHz.

So if you want to use the DAC with 96kHz data, first check that you have TOSLINK receivers capable of 16Mbps. The aforementioned Jaycar ZL3003 are suitable and Altronics now stock a similar part (Cat. Z1604). If you do swap them over, be sure to check that the link selecting 3.3V/5V operation is in the correct location.

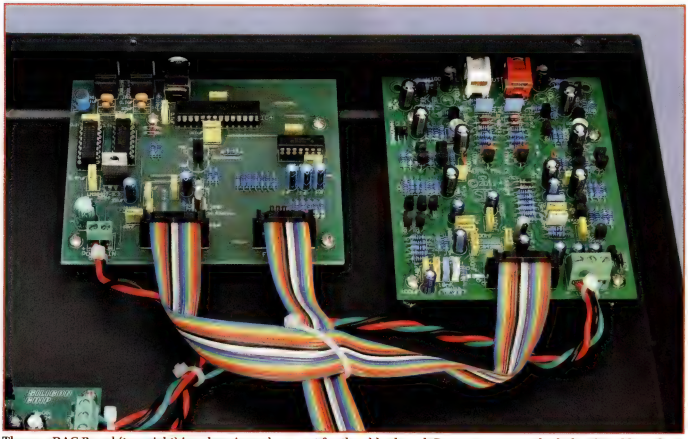
You must then remove the 33pF (or 100pF) capacitors at the outputs of the TOSLINK receivers. While you are at it, be sure to change the 300Ω resistor across the S/PDIF input socket (CON1) to 82Ω (see Notes & Errata, December 2011).

## Table 2: Capacitor Codes

| Value | µF Value | IEC Code | EIA Code |
|---|---|---|---|
| 100nF | 0.1µF | 100n | 104 |
| 18nF | 0.018µF | 18n | 183 |
| 10nF | 0.01µF | 10n | 103 |
| 6.8nF | .0068µF | 6n8 | 682 |
| 4.7nF | .0047µF | 4n7 | 472 |
| 1.8nF | .0018µF | 1n8 | 182 |
| 1nF | .001µF | 1n | 102 |
| 100pF | NA | 100p | 101 |

### Setting up & testing

The new DAC Board can now be tested but first a warning: never apply power to the unit without both CON1 and CON2 (on the DAC board) wired up. If you do, you could damage IC1.



**The new DAC Board (top, right) is a drop-in replacement for the older board. Be sure to connect both the I/O cable and the supply leads befor applying power, otherwise you could damage the DAC chip.**

Check also that the power supply polarity to CON2 is correct before applying power.

Before switching on, turn trimpots VR1 and VR2 fully anti-clockwise, then back clockwise about a quarter of a turn. That done, apply power and check the voltage between TP1 & TP2 using a DMM. You don't need PC pins; just push the probe tips into the test point holes.

The reading should be below 10mV. If it's higher, switch off and check for faults. Also, check the voltage between TP3 & TP4; it should also be less than 10mV.

Assuming these readings are OK, monitor the voltage between TP1 & TP2 and slowly turn VR1 clockwise until you get a reading of about 20mV. That done, repeat this procedure by monitoring TP3 & TP4 and adjusting VR2.

This sets the quiescent current through the output transistors in each channel to around 2mA. That's sufficient for them to operate in class A mode for any load of 1.3kΩ or more. For lower load impedances or highly capacitive loads, the circuit will automatically switch into class B mode. If for some reason you want to drive a 600Ω load in class A mode, increase the quiescent current to 6mA by adjusting VR1 & VR2 for 60mV between the associated test points.

There's no thermal feedback between the $V_{BE}$ multipliers and output stages but at these current levels, transistor self-heating is low and thermal runaway should not occur. Changes in ambient temperature will be compensated for though, as it will affect all transistors more or less equally.

Finally, connect a signal source and check that the sound is undistorted. It's also a good idea to check that the volume control, scanning, muting and so on are all working correctly. This will confirm that the microcontroller can communicate with the DAC IC (IC1).

Once it's up and running, its operation is identical to the original Stereo DAC – see the November & December 2009 issues for further details. SC

## Testing The PCB Without Reprogramming

Communications between the DAC (IC1) and the microcontroller on the other board (via CON1) go via LK1-LK4 which are closely spaced pairs of pads on the underside of the PCB. These are normally shorted with solder.

We could have used permanent tracks instead but this way, it's possible to test the DAC board without having to reprogram the microcontroller. This is because the CS4398 has multiple different configuration modes and the simplest involves tying pins 9-12 either high to +5V (VLC) or tying them low. These are the same pins used for serial communications and they are connected to LK1-LK4.

Most constructors should just short the four links as shown on the overlay diagram, then reprogram the microcontroller. However, if you want to test the new board out first, you can instead connect pins 9-11 of IC1 to the small, nearby 0V pad and pin 12 to the adjacent 5V pad. In this mode, many DAC features do not work properly (eg, the volume control, input scanning and muting) but you can at least verify that the new board is functioning and use it in a limited manner.

# DCC: Digital Command Control For Model Railways

By LEO SIMPSON

**While it has been around for some years now, Digital Command Control or DCC is now becoming increasingly popular as more and more manufacturers incorporate it into their new models, along with various accessories such as complete locomotive sound systems.**

SO WHAT IS DCC? Well, at one time it stood for "Digital Compact Cassette" but the march of technology has consigned that to a technical curiosity. For model railways, DCC is a "packet switching" system whereby multiple locomotives on a model railway layout can be simultaneously controlled. Each locomotive has its own digital address and its speed, direction and a bunch of other parameters such as inbuilt sound and lighting can all be adjusted remotely.

If you are familiar with the Ethernet protocol, one of the original "packet switching" systems, you are well on the way to understanding how DCC works. Of course, a major difference between an Ethernet system and a DCC model railway system is that Ethernet signals are transmitted over Cat.5 cable while DCC signals are broadcast over the rails in the model railway layout.

But we're getting ahead of ourselves. Let's backtrack a little.

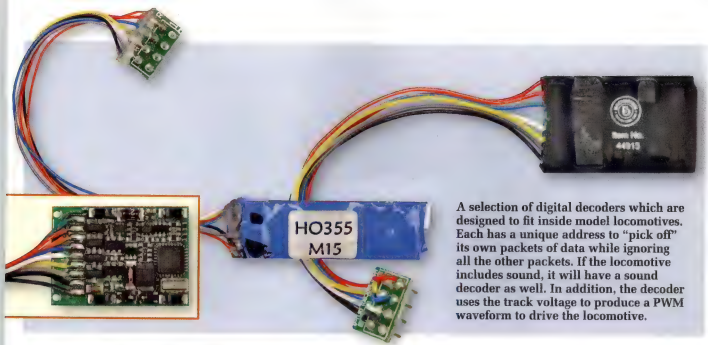
Originally, it was only possible to run one locomotive on a model railway layout. You connected a variable DC power supply to the rails and you varied the track voltage to control the speed of the loco. This is the way it's been done ever since electric model locomotives became available, back in the 1930s.

On early model railways, the speed controllers were really quite crude but with the availability of silicon power transistors from the 1960s onward, model railway speed controllers greatly improved, offering much more realistic operation with simulated inertia (also known as "momentum") and braking. In the late 1970s and early 1980s, the advent of switchmode and pulse-width modulation enabled very realistic low-speed operation of locomotives. The pulsed track voltage was better able to overcome track/wheel contact resistance and motor "stiction".

As well, these electronic controllers were able to monitor the back-EMF voltage from the locomotive motor and thereby provide very good speed regulation, regardless of the load or track gradient. SILICON CHIP has described a number of very good speed controllers incorporating all these features and more.

But as good as these electronic speed controllers are, there is still the limitation that you can only control one locomotive or train at a time. That might be satisfactory if you only have a small circle of track but it rapidly palls if your modelling is more ambitious.

Inevitably, all railway modellers have many locomotives and they want to run more than one at the same time.




**A selection of digital decoders which are designed to fit inside model locomotives. Each has a unique address to "pick off" its own packets of data while ignoring all the other packets. If the locomotive includes sound, it will have a sound decoder as well. In addition, the decoder uses the track voltage to produce a PWM waveform to drive the locomotive.**

Of course, you can run two locomotives if you have two track loops on the one layout board but immediately you want to connect those two loops in any way, you run into serious problems.

On larger layouts, to make operation more realistic, enthusiasts took to dividing them up into blocks (or "cabs" in US parlance), each with a separate speed controller, so you could have an operating locomotive in each block. That meant you could have trains running in different directions on a large layout, as well as shunting operations and so on.

However, that method still only allows one locomotive to operate on the tracks within a block. So if you want to run more locos, you need more blocks and more speed controllers. That rapidly becomes expensive and the necessary wiring and switching to all those blocks becomes very complex and a nightmare when you have to troubleshoot faults.

Then about 30 years ago, a number of model railway companies came up with the concept of "command control" to enable multiple locos to run on a model railway without any need for block switching. The systems included Hornby Zero-One, Dynatrol and CTC-80. A DIY system called the CTC-16 was devised by Keith Gutierrez and the details were published by *Model Railroader* magazine in the early 1980s.

Command control worked by superimposing a serial data stream on the DC supply voltage fed to the tracks. Typically, this would consist of a 5V serial signal added to the 11V or 12V DC to give a total track voltage of 16V or more. The serial data was quite similar to the serial data transmitted to radio-controlled model aircraft, cars and boats to control servos and speed, the major difference being that typically, up to 16 or more locomotives could be controlled simultaneously.

In fact, SILICON CHIP published a Command Control system for Model Railways in 1998 but it and all other Command Control systems are now well and truly obsolete, having been superseded by Digital Command Control, or DCC.

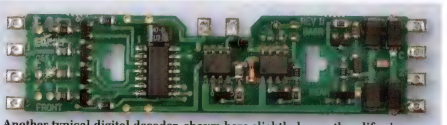
The precursor for DCC was developed by the German company Lenz Electronik GmBH in 1989 and it was incorporated into models made by Marklin and Arnold. Subsequently, other companies produced similar systems but the American modellers' association, the National Model Railroad Association (NMRA) recognised that the lack of standardisation would prevent industry-wide adoption of these systems.

Ultimately, the NMRA adopted and extended the system developed by Lenz in 1993. It promulgated two standards: S-9.1 specifies the electrical standard and S-9.2 specifies the communications standard. For more information on the standards, go to **http://www.nmra.org/**

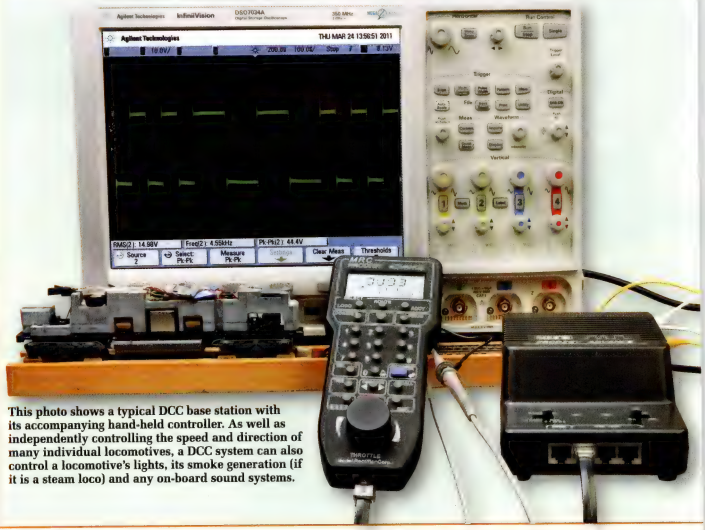
DCC has several big advantages over earlier Command Control systems. First, it can control lots more locomotives on the one model railway layout; up to 99 or more. As well as controlling the speed and direction of each locomotive, a DCC system can also control the locomotive's lights, its smoke generation (if it is a steam loco) and on-board locomotive sound systems which can be very realistic.

An advanced sound system on a steam locomotive may include not only the steam pulses as the locomotive moves, in line with the number of cylinders and the locomotive's speed, but it may also include the sound of the steam-driven air-compressor, bells and steam whistles. To top it off, such sound systems will usually have been sampled from the real (full-scale) locomotives that the models are based on.

Similarly, for a diesel locomotive, the sound system will provide realistic diesel engine and transmission



**Another typical digital decoder, shown here slightly larger than life-size. The decoders are designed to fit inside the model locomotive but can also be hidden inside the tender in the case of steam locos.**




**This photo shows a typical DCC base station with its accompanying hand-held controller. As well as independently controlling the speed and direction of many individual locomotives, a DCC system can also control a locomotive's lights, its smoke generation (if it is a steam loco) and any on-board sound systems.**

sounds where the apparent engine speed matches the loco speed, and may include the over-run sound of turbochargers, bells, air-compressors, air-brake release and 5-chime air-horns. Again, such systems are based on real locomotives and the effects can be startlingly realistic; certainly not as loud but realistic all the same.

As well as controlling the locomotives themselves, the DCC system can control points (turnouts in US parlance), signalling systems, track lighting and so on. Furthermore, some enthusiasts go the whole hog and link the DCC system to a computer and use it to provide CTC (centralised traffic control) on large layouts. It is possible to run a complicated schedule of train movements over a period of several hours and incorporate a "fast clock" to simulate a much longer period of operation.

Naturally, DCC provides very realistic low-speed operation of locomotives as it incorporates all the features of earlier electronic speed controls such as PWM, simulated inertia and braking. Furthermore, to enhance low speed operation, the locomotive's response to increasing track voltage can be programmed to be more progressive. By way of explanation, typical model locomotive motors do not start to rotate until the applied DC voltage voltage goes above about 5V or 6V. Once this is programmed out, the speed of the locomotive will appear much more linear with respect to what is dialled in on the throttle control.

## DCC track voltage

We have already mentioned that DCC is similar to the Ethernet protocol and that it employs a "packet switching system" to send control data via the model railway tracks to the various locomotives. So DCC uses a microcontroller to generate all the necessary serial data. Each locomotive is sent its own "packets" of serial data and as you can imagine, in a system which can handle of lot of locomotives, there will be a large number of packets being broadcast in the serial data on the railway tracks.

In a typical DCC installation, you will have one base station which is essentially a big power supply controlled by the microcontroller mentioned above. The user will have a hand-held remote controller which can individually select every locomotive and all the accessories on the layout. So each packet of serial data is under the control of the user and all packets remain the same until he (or she) dials in a new value to vary a loco speed, switch points, turn on lights or whatever.

Each locomotive has its own inbuilt digital decoder with a unique address to "pick off" its own packets of data while ignoring all the other packets. If the locomotive includes sound, it

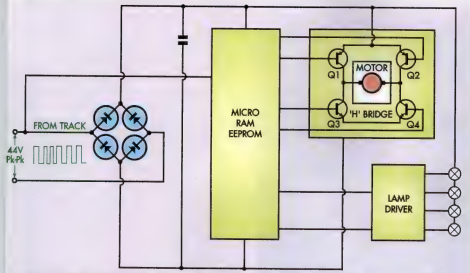



**Fig.1: block diagram of a typical locomotive decoder. It picks up power and data from the rails of the model layout via a bridge rectifier and includes a microcontroller which drives an H-bridge circuit (Q1-Q4). This drives the loco's motor in forward or reverse using a pulse-width modulated voltage that's unrelated in frequency or pulse width to the track voltage.**

**Fig.2: the track signal is typically somewhere between ±15V or ±22V peak (or 30 to 44V peak-to-peak). Each data packet is preceded by two large width pulse transitions, followed by the data.**

will have a sound decoder as well. The user does not have to worry about controlling the sound features as they automatically change whenever one of the loco's speed settings is changed. Having said that, the user can sound the loco's whistle, horns or flashing lights whenever that is desired.

As its name suggests, the decoder decodes the packets of data and the same PCB uses the track voltage to drive the locomotive. The bipolar pulse track voltage is rectified to provide a DC rail which is fed to an H-bridge circuit to drive the motor with its own pulse width modulated voltage. And as mentioned previously, it also drives the lighting and other locomotive functions.

Fig.1 shows the block diagram of a typical locomotive decoder. Essentially, it draws power and data from the rails of the model layout. As you can see, the micro drives an H-bridge circuit which is more or less identical to those used in any SILICON CHIP Railpower model train controller. The H-bridge drives the loco's motor in forward or reverse and with a pulse-width modulated voltage which is completely unrelated in frequency or pulse width to the track voltage.

That makes sense but it is a little mind-boggling that you could have 20 locomotives simultaneously operating on a large layout, all with different speed and direction settings and all unrelated to the track signals.

Fig.2 shows the track signal and it is typically somewhere between ±15V or ±22V peak (or 30 to 44V peak-to-peak). Each data packet is preceded by two large width pulse transitions, followed by the data. Two scope grabs of an actual DCC track signal are included in this article. If you look closely, you will see that the nominal track voltage is close to ±15V peak or 30V peak-to-peak. However, there is about 7V of overshoot on each pulse transition.

Notice that the signal waveform is exactly bipolar and there is no DC component. The signal frequency is around 4.7kHz.

(Some DCC base stations have a feature whereby they can control


# Silicon Chip Binders

These binders will protect your copies of SILICON CHIP. They feature heavy-board covers & are made from a distinctive 2-tone green vinyl. They hold 12 issues & will look great on your bookshelf.

★ 80mm internal width

★ SILICON CHIP logo printed in gold-coloured lettering on spine & cover

★ Buy five and get them postage free!

**Price: $A14.95 plus $A10.00 p&p per order. Available only in Aust.**

**Silicon Chip Publications**
**PO Box 139**
**Collaroy Beach 2097**

Or call (02) 9939 3295; or fax (02) 9939 2648 & quote your credit card number.

**Use this handy form**

Enclosed is my cheque/money order for

$_____ or please debit my

❑ Visa ❑ Mastercard

Card No:

_____

Card Expiry Date ____/____

Signature _____

Name _____

Address _____

_____ P/code_____

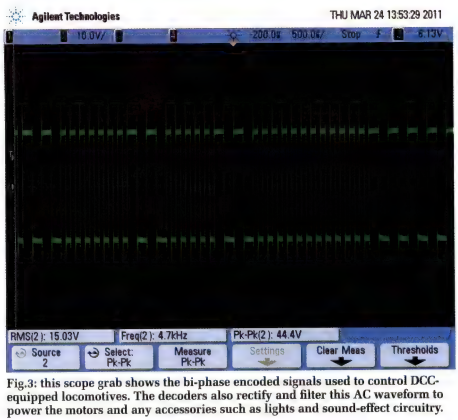



**Fig.3: this scope grab shows the bi-phase encoded signals used to control DCC-equipped locomotives. The decoders also rectify and filter this AC waveform to power the motors and any accessories such as lights and sound-effect circuitry.**

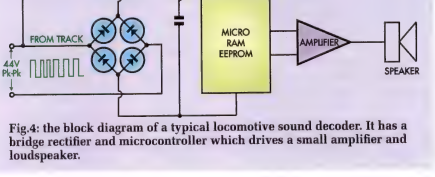



**Fig.4: the block diagram of a typical locomotive sound decoder. It has a bridge rectifier and microcontroller which drives a small amplifier and loudspeaker.**

non-DCC locomotives. The method involves deliberately changing the duty cycle of the DCC waveform so that it does have a varying DC component to drive the motor. However, this practice cannot be recommended since it applies a high AC voltage to the loco motor which can cause considerable heating, especially with coreless motors).

Fig.4 shows the block diagram of a typical locomotive sound decoder. Again, it has a bridge rectifier and a microcontroller, the latter driving a small amplifier and loudspeaker. Naturally, depending on the scale of the locomotive, the speaker is quite tiny and is housed with the loco's body or the decoder and loudspeaker may in the tender, in the case of a steam locomotive.

While the block diagrams of Fig.1 & Fig.4 are quite simple, the actual decoders are surprisingly complex. What makes it all possible is that they use surface-mount parts; it just would not be possible if conventional though-hole parts were all that were available.

Other accessory decoders are similar in principle to that shown in Fig.1, as all use a bridge rectifier and microcontroller. However, they may have solenoid or motor drivers in the case of points (turnouts) or lamp drivers in case of track signalling or lighting.

## Adopting DCC

So if you are a keen railway modeller and you are contemplating changing over from a conventional model layout with block wiring, what do you need to do? Can you run DCC and non-DCC models on the same layout?

The answer is "yes but". There are two approaches you could take. First, you could continue to employ the conventional block wiring system and your existing train controllers together with a DCC base station and one or more DCC-equipped locomotives. Then you could switch control of DCC locos through the various blocks as you would in a non-DCC system with conventional train controllers.

What if your layout has no block switching? Then you are rather stymied unless you have a DCC base station which can be set up to drive non-DCC locomotives, as mentioned above. But as noted, the process is definitely not recommended.

Which leaves you with biting the bullet and just going straight to the DCC approach: buy a DCC base station and as many DCC decoders as you need; one for each locomotive. Points, signalling and lighting decoders can come later. Your main expense will be the DCC base station and controller. Since all decoders are compatible with all base stations, you can shop around for decoders and they can be picked up very cheaply.

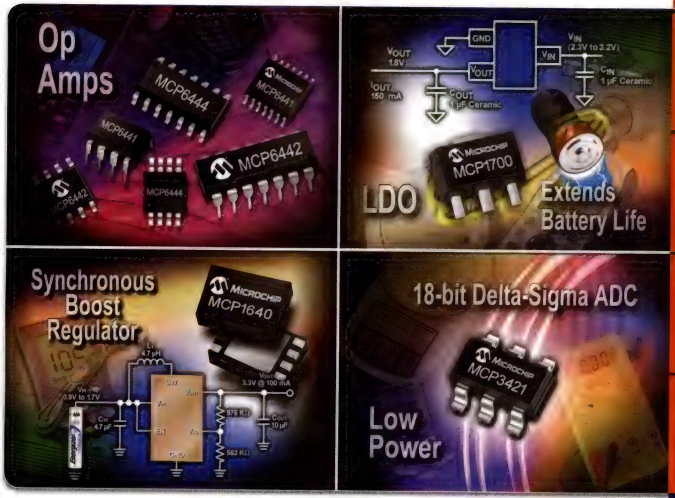
Fitting the DCC decoder to each locomotive is matter of pulling it apart and first finding the space to install it. Then you have to disconnect the loco's motor from the track collectors and connect those wires to the power input on the DCC decoder. Then you take the two output wires from the DCC decoder and connect them to the motor. Connecting the loco's lights can be trickier but is essentially straightforward. It is then simply a matter of securing the decoder and re-assembling the loco.

Making your own decoders is really not practical since they are so tiny and densely packed with surface-mount devices. And they are really quite cheap – shop around on the internet.

Similarly, in view of their complexity, building DCC base stations and controllers is also not practical. However, we would not rule out DCC projects from appearing in future issues of SILICON CHIP. The most obvious one is a DCC booster, to increase the current output of any DCC base station, to cater for large layouts. SC

# Need A Wide Variety Of Analog Products?

## See What Microchip's Uninterrupted Supply Can Do For You




Microchip offers a broad portfolio of low power analog products that support a wide variety of applications. With over 500 unique stand-alone analog products covering thermal management, power management, battery management, mixedsignal, linear, interface and safety and security.

Microchip's analog product selection offers a complete solution for all of your standalone analog needs, or together with one of the many PIC® MCUs offered by Microchip.

**Microchip Technology Australia**
Tel: (02) 9868 6733 E-mail: aust_nz.inquiry@microchip.com

microchip DIRECT
www.microchipdirect.com

www.microchip.com/analog

MICROCHIP

Microcontrollers | Digital Signal Controllers | Analog | Memory | RF & Wireless

The Microchip name and logo, the Microchip logo and PIC are registered trademarks of Microchip Technology Incorporated in the USA and other countries. All other trademarks mentioned herein are property of their respective companies. © 2012 Microchip Technology Incorporated. All rights reserved.

# SemTest

Pt.1: By JIM ROWE

## Check all those semiconductors in your collection with this easy-to-build test set!

**How many discrete semis have you got in your collection? Hundreds? Thousands? Are they all good? Don't know? With our new Discrete Semiconductor Test Set you will be able to test a wide range of active components: LEDs, Diodes, Bipolar Junction Transistors, Mosfets, SCRs and Programmable Unijunction Transistors (PUTs), for gain (where applicable), voltage breakdown and leakage. You can even run tests on IGBTs and Triacs!**

OF COURSE, THERE are lots of semiconductor testers out there. These range from the handy pocket-sized instruments produced by Peak Electronic Design Ltd in the UK to large laboratory bench instruments made by Agilent and costing many thousands of dollars. The former group are not able to test the range of semiconductors that we would like, while the latter instruments are beyond the reach of all but a few research labs.

So Publisher Leo Simpson set me the task of producing a new design. It had to be easy to drive and would be somewhat similar in concept to the "Test Set For Transistors & Diodes" featured in *Electronics Australia* magazine way back in the July and August 1968 issues (yes, back in the olden days – and it was my design too!).

It was pretty simple – using a bunch of rotary switches, a 50µA moving coil meter and olde-worlde point-to-point wiring – but it could perform most of the basic tests that were needed on the discrete semiconductor devices of the day.

I took one look at that old 1968 design and shuddered: all that point-to-point wiring – all those switches – no PCB – an analog meter. Gaaakkk! What could Leo be thinking? Not only that,

it was designed long before Mosfets were even thought of and we would have to include them, of course.

In the fullness of time (a silly expression glossing over the trials and tribulations – not to mention the blood, sweat and tears – of producing a completely new design), we came up with the SemTest. It's otherwise known as a Discrete Semiconductor Test Set – which is too much of a mouthful.

It's around half the physical size of the 1968 design and it's controlled by a microprocessor, with a 16x2 LCD panel used to display the device to be tested, the test to be run and the test results. There are a minimum of front panel controls: one rotary switch, one pot and five pushbuttons. And the curly problem of catering to all the different semiconductor sizes and pin-outs has been solved by employing an 18-pin ZIF (zero insertion force) socket.

These sockets are normally used for programming microprocessors but they are ideal for this application.

All the parts inside the case are accommodated on two medium-sized PCBs which are connected together by three IDC cables.

However, before we jump into describing the circuitry of the SemTest in detail, we need to discuss the tests it can perform on each type of the most commonly used discrete semiconductors. After all, if you are contemplating building the SemTest, you will want to understand all the tests that it can run.

## Diodes & LEDs

These sound simple enough but there are different sorts: standard silicon and germanium signal & rectifier diodes, zener/avalanche diodes, schottky barrier diodes, LEDs and Diacs (bipolar breakover diodes, which are actually a 2-terminal thyristor). The new tester can perform basic tests on all of these devices.

A simplified version of the diode test circuitry used in the SemTest is shown in Fig.1. It's very straightforward, yet can be used to measure any of four basic diode parameters:

**(1) $V_F$** – the voltage drop when conducting in the forward direction;

**(2) $I_R$** – the leakage current which flows when a reverse "operating" voltage (OPV) of 10V/25V/50V/100V is applied via an appropriate series current limiting resistance;

**(3) $I_R$** – the current which flows when a higher "breakdown" voltage (BV) of 600V is applied (again via a suitable series current limiting resistor); and

**(4) $V_R$** – the voltage drop when the diode is conducting in the reverse direction in "avalanche" breakdown mode.

All four of these tests can be applied to test zener/avalanche diodes, signal & rectifier diodes, schottky diodes and even Diacs. The last two tests are not available for testing LEDs as these devices can be damaged if sufficient current flows during avalanche breakdown.

In fact, before you do an $I_R$ test on a LED, the SemTest warns you of possible damage if the lowest operating voltage of 10V is not selected.

The diode test circuit of Fig.1 uses RELAY9 to switch the polarity of the diode under test. When RELAY9 is off (not energised), the diode's anode (A) is connected to the test voltage source (+V) via series current-limiting resistor $R_{SERIES}$.

Note that test voltage +V is switched between the operating voltage (OPV) and the breakdown voltage (BV) level by the microcontroller, which also changes the value of series resistor

**TESTS AVAILABLE ON THE DISCRETE SEMICONDUCTOR TEST SET**

| Device Type | Test Parameter | Extended description |
|---|---|---|
| Diodes, including zener & schottky (also Diacs) | $I_R$ (BV) | Reverse avalanche current with BV (600V) applied* |
| | $I_R$ (OPV) | Reverse leakage current with OPV (10/25/50/100V) applied* |
| | $V_F$ (OPV) | Forward voltage drop with OPV (10/25/50/100V) applied* |
| | $V_R$ (BV) | Zener/avalanche voltage with BV (600V) applied* |
| LEDs | $I_R$ (OPV) | Reverse leakage current with OPV (10V) applied* |
| | $V_F$ (OPV) | Forward voltage drop with OPV (10/25/50/100V) applied* |
| Bipolar Junction Transistors (NPN or PNP) | $V_{(BR)CBO}$ (BV) | Breakdown voltage with e o/c, BV (600V) applied* |
| | $V_{(BR)CEO}$ (BV) | Breakdown voltage with b o/c, BV (600V) applied* |
| | $I_{CBO}$ (OPV) | Leakage current with e o/c, OPV (10/25/50/100V) applied* |
| | $I_{CEO}$ (OPV) | Leakage current with b o/c, OPV (10/25/50/100V) applied* |
| | $h_{FE}$ with $I_B$ = 50µA (OPV) | Forward current gain with $I_B$ = 50µA, OPV applied* |
| | $h_{FE}$ with $I_B$ = 200µA (OPV) | Forward current gain with $I_B$ = 200µA, OPV applied* |
| | $h_{FE}$ with $I_B$ = 1mA (OPV) | Forward current gain with $I_B$ = 1mA, OPV applied* |
| Mosfets (N-channel or P-channel) | $V_{(BR)DSS}$ (BV) | Breakdown voltage with g-s short, BV (600V) applied* |
| | $I_{DSS}$ (OPV) | Leakage current with g-s short, OPV (10/25/50/100V) applied* |
| | $I_{DS}$ vs $V_{GS}$ (OPV) ($g_m$) | d-s current vs $V_{GS}$ (0-12V), OPV (10/25/50/100V) applied* |
| SCRs & PUTs (also Triacs) | $V_{(BR)KGS}$ (BV) | Breakdown voltage with g-k or g-a short, BV (600V) applied* |
| | $I_{AKS}$ (OPV) | a-k current with g-k or g-a short, OPV (1/25/50/100V) applied* |
| | $I_{AK}$ with $I_C$ = 50µA (OPV) | a-k current with $I_C$ = 50µA, OPV (1/25/50/100V) applied* |
| | $I_{AK}$ with $I_C$ = 200µA (OPV) | a-k current with $I_C$ = 200µA, OPV (1/25/50/100V) applied* |
| | $I_{AK}$ with $I_C$ = 1mA (OPV) | a-k current with $I_C$ = 1mA, OPV (1/25/50/100V) applied* |
| | $V_{AK(ON)}$ (OPV) | a-k voltage drop when on, OPV (10/25/50/100V) applied* |

*Both BV and OPV are always applied via appropriate current limiting series resistors

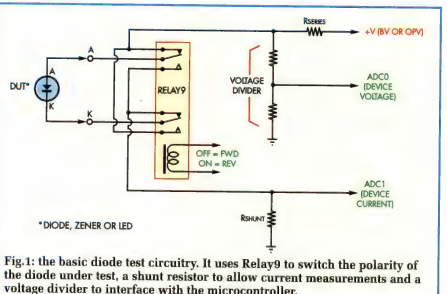
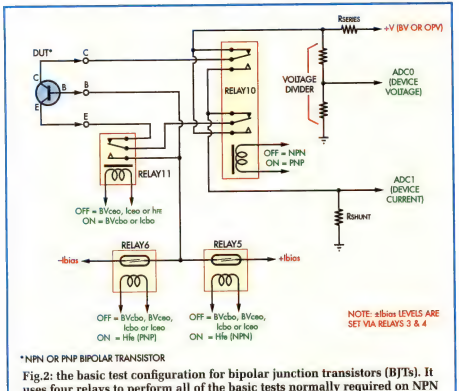



**Fig.1: the basic diode test circuitry. It uses Relay9 to switch the polarity of the diode under test, a shunt resistor to allow current measurements and a voltage divider to interface with the microcontroller.**




*NPN OR PNP BIPOLAR TRANSISTOR

**Fig.2: the basic test configuration for bipolar junction transistors (BJTs). It uses four relays to perform all of the basic tests normally required on NPN or PNP devices.**

RSERIES to suit the various tests. In operation, the micro switches +V on only during the actual test and then off again at the end of the test.

For the "reverse bias" tests, the micro energises RELAY9 which simply reverses the diode polarity so that the cathode (K) is connected to +V instead of the anode.

The rest of the diode test circuit includes a voltage divider, used to allow the micro to measure the voltage across the diode under test, by means of the micro's analog-to-digital (A/D) converter input ADC0. The micro also switches the voltage divider's ratio to suit the voltage source used for each test.

Finally, there's a shunt resistor (RSHUNT) connected between the cathode (or anode) of the diode and ground. The top of this resistor is connected to the ADC1 input of the micro so it can measure the voltage across RSHUNT and then calculate the device current. Again, the value of RSHUNT is switched by the micro, in this case to suit the current range required for the selected test.

By the way, since the voltage drop across RSHUNT effectively adds to the device voltage as measured via the voltage divider and the microcontroller's ADC0 input, this has the potential to introduce a small error in the device voltage measurement. This voltage drop across RSHUNT is quite small, with a maximum of 2.0V for a "full scale" current reading of 20mA (or 200µA on the low range).

To eliminate this problem, the firmware automatically corrects the reading. It does that by subtracting 100mV for each 1mA of device current on the higher range, or for each 10µA of current on the low range (ie, it automatically subtracts the voltage across the RSHUNT).

## Testing Diacs

Before we move on, let's look at how a Diac can be tested with the SemTest. It should connected to the diode A and K terminals (either way around) and first given the diode $V_F$ test with the lowest (10V) setting for OPV. This will show you whether the Diac is shorted (which will give a reading of no more than about 0.25V and a current of about 2.5mA) or "OK" (which will give a reading of close to 10V).

If you do get a reading of very close to 10V, you can repeat the above test at 25V or 50V until the Diac breaks over into conduction. Typical Diacs break over at between 25V and 35V, with a current of less than 200µA.

When the Diac does switch into conduction, the $V_F$ reading suddenly drops to a much lower level – probably around 5-10V – while the current jumps up into the 3-10mA region. If the Diac behaves as described, you then do the test in the other direction: ie, switch back to the 10V setting for OPV and then test it with the $I_R$ (OPV) test selected.

This will let you check the Diac's operation in the reverse direction. You should again see it drawing a current of less than 200µA with only 10V applied, with the current jumping up to between 5mA and 15mA when you select an operating voltage of 25V or 50V so that it "breaks over" again.

If your Diac gives these expected results in both tests, it is working as it should.

## Testing transistors

Testing bipolar junction transistors or "BJTs" is more complex than with diodes, because there are NPN and PNP types and they have three leads rather than two. Fig.2 shows the test configuration for BJTs. This uses four relays to perform all of the basic measurements normally required for NPN or PNP devices:

**(1) $I_{CBO}$** – the leakage current passed between collector and base, with a selected operating voltage (OPV) applied and the emitter open-circuit;

**(2) $I_{CEO}$** – the leakage current passed between collector and emitter, again with a selected operating voltage (OPV) applied but this time with the base open-circuit;

**(3) $V_{(BR)CBO}$** – the breakdown voltage measured between collector and base, with the emitter open-circuit but with a breakdown voltage (BV) source applied via a series current-limiting resistor;

**(4) $V_{(BR)CEO}$** – the breakdown voltage measured between collector and emitter, with the base open circuit but with a breakdown voltage (BV) source applied via a series current-limiting resistor; and

**(5) $h_{FE}$** – the common-emitter forward current gain, measured at any of three base current levels ($I_B$ = 50µA, 200µA or 1mA). The choice of base current levels is provided to cope with small and medium-power devices.

As you can see from Fig.2, RELAY10 is used for setting up the BJT circuit for testing either NPN or PNP devices. RELAY11 is used to perform the base/emitter switching for the various tests,

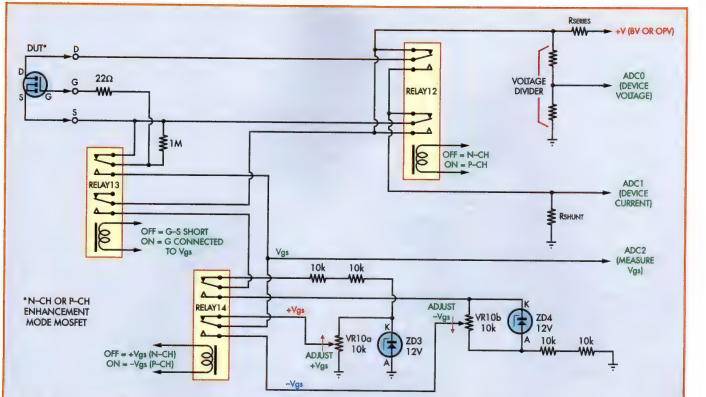



**Fig.3: the Mosfet test circuit. Only three relays are used and these allow all the main tests normally required for both N-channel and P-channel Mosfets. The positive $V_{GS}$ (gate-source) voltage is derived from zener diode ZD3 and varied by VR10a, while the "negative" $V_{GS}$ voltage is derived from ZD4 and varied by VR10b.**

while RELAY5 is used to switch on positive base bias current (+$I_{BIAS}$) for $h_{FE}$ testing of NPN devices. RELAY6 is used to switch on negative base bias current (-$I_{BIAS}$) for $h_{FE}$ testing of PNP devices.

Additional relays (RELAY3 and RELAY4, not shown in Fig.2) are used to switch both +$I_{BIAS}$ and -$I_{BIAS}$ between the various current levels.

As with the diode testing circuit, either operating voltage (OPV) or breakdown voltage (BV) can be applied to the transistor being tested, via series current-limiting resistor RSERIES. Again the micro switches the OPV/BV source on only for the actual test, and then off when the test is ended. It also changes the value of RSERIES to suit each kind of test.

As before, there is a voltage divider across the device being tested, feeding the micro's ADC0 input so that the micro can measure the device voltage $V_{DEV}$. Again, the micro changes the divider ratio to suit each kind of test. The device current is also measured in exactly the same way as for diodes, with shunt resistor RSHUNT used to effectively convert the device current into a small voltage for measurement via the micro's ADC1 input. The micro can also switch the value of RSHUNT to provide two current ranges: 20mA and 200μA.

We should point out here that, as before, the small voltage drop across RSHUNT will effectively add to the device voltage measurement, introducing a small measurement error for $V_{(BR)CBO}$ and $V_{(BR)CEO}$. Again the software corrects for this error by subtracting 100mV for each 1mA of device current on the higher range, or for each 10μA of current on the low range.

## Testing Mosfets

Testing metal-oxide-semiconductor field effect transistors or "Mosfets" is not significantly more complicated than with BJTs, even though Mosfets are a voltage-controlled transconductance device rather than a current-controlled transadmittance device.

As with BJTs there are again two types, in this case N-channel and P-channel devices, with different polarity requirements for both drain-source voltage and gate bias voltage. There's also a difference in terms of breakdown voltage and leakage current measurement, of course.

Note, however, that the SemTest is only capable of testing junction FET or "JFET" devices in a limited sense, as these operate in depletion mode rather than in enhancement mode as used by modern Mosfets.

Whereas Mosfets pass virtually zero drain-source current with zero gate bias and need gate bias in order to pass significant drain-source current, JFETs work the other way around; they pass a significant drain-source current with zero gate bias and need gate bias to be applied in order to "throttle back" the drain-source current. This means they require "negative" gate bias, in contrast with the "positive" bias needed by Mosfets.

Despite this limitation, the SemTest is capable of testing JFETs for one quite important parameter: $I_{DSS}$ – the drain-source gate current with the gate tied to the source (ie, the zero-bias channel current). This is done via the same Idss test used for Mosfets (see below), the difference being that with Mosfets the reading should be very low (usually well below 200μA), while for JFETs the reading will be relatively high (probably 10-20mA).

The Mosfet test circuit is shown in simplified form in Fig.3 and it's relatively straightforward. Only three relays are used but these allow the

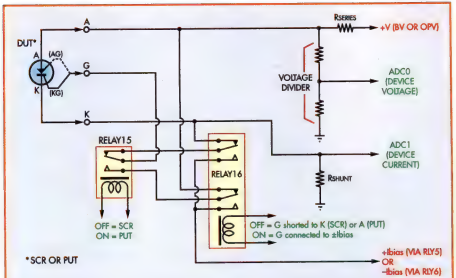



**Fig.4: the test circuit for SCRs and PUTs uses two relays for switching and is similar to that used to test bipolar junction transistors (BJTs). It carries out five basic tests.**

SemTest to perform all three of the main tests normally needed for either N-channel or P-channel Mosfets:

**(1) $I_{DSS}$** – the drain-source current with zero gate bias (ie, gate tied to source). This can be measured with any selected operating voltage (OPV) applied between drain and source, via a series current-limiting resistor;

**(2) $V_{(BR)DSS}$** – the drain-source breakdown voltage, again measured with gate tied to source but in this case with the higher voltage source (BV) applied between drain and source, via a higher-value current limiting resistor; and

**(3) $I_D$** – the drain-source current which flows at any gate bias voltage $V_{GS}$ (variable between 0V and approximately 12V), with any selected operating voltage (OPV) applied between drain and source. This allows the transfer characteristic of a device to be measured, and its transconductance worked out.

As you can see from Fig.3, the Mosfet drain-source voltage and drain current are measured in exactly the same way as for BJTs and diodes, using a voltage divider feeding ADC0 for the voltage measurement and shunt resistor RSHUNT feeding ADC1 for the current measurement. The OPV/BV switching and RSERIES switching are managed by the micro as before, as is the voltage divider ratio and the value of RSHUNT.

The main differences between Fig.3 and the earlier test circuits are in the gate switching circuitry, involving RELAY13 and RELAY14. The first of these relays carries out the primary gate switching, shorting the Mosfet's gate to the source for the $I_{DSS}$ and $V_{(BR)DSS}$ tests when it is not energised or connecting the gate to a bias voltage source $V_{GS}$ when it is energised (for the $I_D$ versus $V_{GS}$ test).

RELAY14 then performs the job of selecting either a "positive" $V_{GS}$ source for N-channel devices, or a "negative" $V_{GS}$ source for P-channel devices.

The positive $V_{GS}$ source is derived from the test voltage (OPV) via zener diode ZD3 and varied by potentiometer VR10a, while the "negative" $V_{GS}$ source is also derived from OPV but via ZD4 and varied by VR10b. The latter is only negative by comparison to the Mosfet's source terminal, which in the case of a P-channel device is connected to OPV.

This explains why VR10a is adjusted upwards from ground (0V) to increase $+V_{GS}$ (for N-channel devices), while conversely VR10b is adjusted downwards from the device source voltage (representing zero $V_{GS}$) to increase $-V_{GS}$ for P-channel devices.

Since VR10a and VR10b are the two sections of a dual-ganged 10kΩ+10kΩ pot, they are simply wired in converse fashion so that the effective gate-source voltage advances from zero as the pot is turned clockwise.

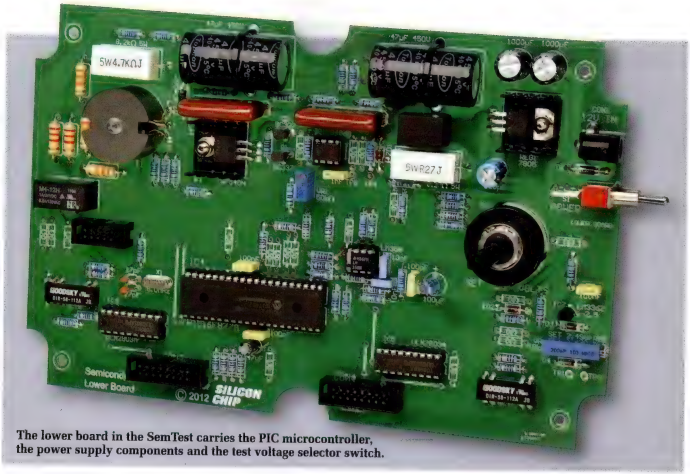
The micro is able to work out the effective gate voltage for any setting of VR10a or VR10b via the connection from the $V_{GS}$ source, as selected by RELAY14, to a third ADC input of the micro (ADC2). But because this only allows the micro to measure the "raw" gate voltage $V_G$, relative to ground, this means that for P-channel devices it also has to measure the source-drain voltage of the device and subtract the measured gate voltage from it, to calculate the effective gate-source bias ($-V_{GS}$).

With N-channel devices this isn't necessary, although the small voltage developed across current measuring shunt resistor RSHUNT will reduce the effective gate-source bias for these devices, by the same factor of 100mV for each 1mA of current on the higher current range or 10µA of current on the lower range.

As with the $h_{FE}$ measurements for BJTs, the firmware automatically makes this correction.

## What about IGBTs?

Although they're not widely used in general electronics, insulated-gate bipolar junction transistors or IGBTs




**The lower board in the SemTest carries the PIC microcontroller, the power supply components and the test voltage selector switch.**

are encountered in automotive ignition systems, fuel-injection controllers, high power inverters and AC induction motor drives.

They can be regarded as very much like an N-channel Mosfet and an NPN BJT/PNPN silicon-controlled switch combined, with a collector as the main positive electrode and an emitter as the main negative electrode. However, they have a gate electrode for voltage control instead of a base electrode for current control.

IGBTs are usually quite high-power devices, so the modest test currents available inside the SemTest mean that it isn't really possible to use it to fully characterise the performance of an IGBT.

However, you can perform basic tests on an IGBT by connecting it to the SemTest's Mosfet testing terminals (C to the drain terminal, E to the source terminal and G to the gate terminal). You then test it as if it were an N-channel Mosfet, making a mental conversion of the test results into the equivalent parameters for an IGBT.

For example, the voltage reading you get for $V_{(BR)DSS}$ will correspond to the IGBT's $V_{(BR)CES}$ (collector-emitter breakdown voltage with the gate shorted to the emitter), while the reading you get for $I_{DSS}$ will correspond to the IGBT's $I_{CES}$ (collector-emitter leakage current with gate shorted to emitter).

You'll even be able to get an idea of the IGBT's gate threshold voltage $V_{GE(TH)}$, by using the Mosfet $I_D$ vs $V_{GS}$ test and finding the gate voltage where $I_D$ (corresponding to the IGBT's collector-emitter current $I_{CE}$) begins rising from its $I_{CES}$ "off" level.

## Testing SCRs & PUTs

The fourth main type of discrete semiconductor device that the SemTest is capable of testing is thyristors or silicon-controlled switches (SCSs) – in particular, SCRs (silicon-controlled rectifiers) and PUTs (programmable unijunction transistors).

Note that another name for an SCR is a cathode-gate SCS, while a PUT is more accurately described as an anode-gate SCS. They are both PNPN devices, and similar apart from the different gate connections. So in that sense they are essentially just two different "flavours" of SCS devices, like NPN and PNP bipolars or N-channel and P-channel Mosfets.

As a result, the circuitry needed for testing SCRs and PUTs is not all that different from that needed for BJTs, as can be seen from the simplified circuit shown in Fig.4.

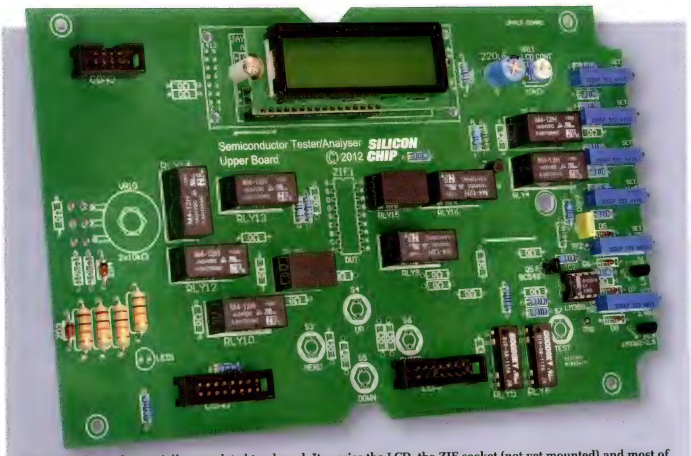
Despite its simplicity, this circuit allows the following measurements to be carried out on SCRs and PUTs:

**(1) $V_{(BR)AKS}$** – the breakdown voltage for an SCR, with its gate tied to the cathode and a source of high voltage (BV) applied between anode and cathode via the usual current-limiting resistor $R_{SERIES}$;

**(2) $V_{(BR)AKS}$** – the breakdown voltage for a PUT, in this case with its gate tied to the anode and the high voltage (BV) applied between anode and cathode, again via $R_{SERIES}$;

**(3) $I_{AKS}$** – the anode-cathode current for either an SCR or a PUT, with its gate tied to either the cathode (SCR) or anode (PUT), and with any selected operating voltage (OPV) applied between anode and cathode via a current-limiting resistor $R_{SERIES}$. In other words, the "OFF" current of the device;

**(4) $I_{AK}$** – the anode-cathode current for either an SCR or a PUT, with any selected operating voltage (OPV) applied between anode and cathode, and its gate connected to any of three sources of bias current: +50μA, +200μA or +1mA in the case of an SCR, or -50μA, -200μA or -1mA in the case of a PUT.




**This view shows the partially-completed top board. It carries the LCD, the ZIF socket (not yet mounted) and most of the relays. It's connected to the bottom PCB via three IDC cables.**

These measurements allow you to gain a good idea of the device's triggering sensitivity; and

**(5) $V_{AK}$** – the anode-cathode voltage for either an SCR or a PUT when it has switched ON and is conducting. In other words, Vak is the device voltage drop in its conducting state.

These measurements are really all that are needed to test and roughly characterise most PUTs and low-to-medium-power SCRs in general use. But please note that because of current limitations, the SemTest is not really capable of testing high-power SCRs – except in a basic "shorted or open" sense.

Apart from anything else, the maximum gate bias current provided by the SemTest is only 1mA, which may not be enough to trigger a high-power SCR.

As shown in Fig.4, the device voltage and current measurement arrangements for SCRs and PUTs are exactly the same as for BJTs. The only real differences are with regard to gate switching, where RELAY15 controls the initial SCR/PUT switching and RELAY16 controls whether the gate is connected to the cathode (SCR) or anode (PUT), or to a bias current source (via RELAY5 or RELAY6, with the actual bias current level selected via RELAY3 and RELAY4).

## Triac testing

Triacs are another common form of discrete thyristor device, more widely encountered than SCRs. They're used to control mains AC in many electrical appliances.

Because Triacs are essentially gate-controlled AC switches, the only way to fully characterise their behaviour is in a tester which allows them to be tested under AC conditions. However, because a Triac is very much like a pair of SCRs connected in inverse parallel, it's possible to use the SemTest's SCR/PUT tests to perform a full range of measurements on a Triac.

For example, if you connect a Triac to the SemTest's SCR terminals with its A1 electrode connected to the cathode terminal, its A2 electrode to the anode terminal and its gate to the gate terminal (where else?), you can do all the SCR tests described above, ie, $V_{(BR)AKS}$, $I_{AKS}$ and $I_{AK}$ for any of the three levels of $+I_{BIAS}$ and even $V_{AK(ON)}$. So you can give it a fairly thorough "DC workout" in its main operating "quadrant".

If you then leave it connected in exactly the same way but this time check it as if it were a PUT, you can thoroughly test it in a second quadrant. Finally, if you swap the A1 and A2 electrode connections so that A2 goes to the cathode terminal and A1 to the anode terminal, you will be able to test it in the other two quadrants, ie, by testing it again as an SCR and then as a PUT.

So for a quick and dirty test, you just run the SCR tests on the Triac for just one quadrant. If you want to test in the other three quadrants, you need to run the tests three more times, as just described.

The only limitation to this procedure is that the maximum gate bias current which the SemTest can provide is ±1mA, which as with SCRs may simply not be enough to trigger high-power Triacs.

## Summary

That should give you a good idea of the discrete semiconductor devices that our new SemTest is capable of testing and measuring. Next month, we will present the full circuit details and start the construction. **SC**

# DO IT YOURSELF

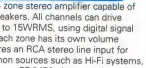
**February Back To Work Projects!**

More DIY tools on pages 2 & 3

## 4 ZONE CLASS D AMPLIFIER

A simple to use 4 zone stereo amplifier capable of driving up to 8 speakers. All channels can drive speakers with up to 15WRMS, using digital signal processing and each zone has its own volume attenuator. Features an RCA stereo line input for connecting common sources such as Hi-Fi systems, DVD/Blu-Ray players, CD/MP3 players and radios. Mountable and expandable by adding a line loop out creating your ideal system. Requires 12VDC 9A power adaptor

**(MP-3241** $79.95).



- Power: 8 x 15WRMS
- Minimum Impedance: 4 ohm
- Frequency Response: 20hz-20kHz
- Size: 108(W) x 205(D) x 26(H)mm

**AA-0469**

NEW

**$129.00**

## IP67 TRUE RMS CAT IV DMM WITH WIRELESS USB & STORAGE

Features double moulded case for impact resistance and IP67 waterproof protection. This meter can also be used as a data logger with its data storage capability, which can then be connected to a PC via wireless USB interface keeping the PC completely isolated from whatever is being measured. A truly fantastic multimeter designed to last you several years out in the field.

- LCD backlit
- True RMS
- Data hold, autoranging
- PC logging software
- 9999 measurement storage
- Auto power-off
- 10A max AC or DC
- 1000V max AC or DC
- Size: 182(H) x 82(W) x 56(D)mm

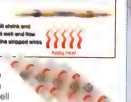
**QM-1575** WAS $199.00

**SAVE $20.00**

**$179.00**

## SOLDER SPLICE HEATSHRINK TUBING

Allows you to quickly join two cables by sliding a tube over the join in and heating as you would any other shrink tube. As the tube shrinks the solder melts to electrically connect the wires resulting in a join which is reliable and well insulated.




- Three sizes available in packs of 5

| | | |
|---|---|---|
| 2.7mm | **WH-5670** | $4.95 |
| 4.5mm | **WH-5671** | $4.95 |
| 6.0mm | **WH-5672** | $4.95 |

**$4.95 ea.**

## 10MHz HANDHELD POCKET SCOPE

NEW

A complete portable oscilloscope with a tiny size. With many features found on full size digital scopes you'll wonder how they squeezed all of it into a package a little larger than a Smartphone. Aside from standard scope features, it has nifty tools for measurement of RMS speaker power, display hold function, and memory storage for 2 signals. Housed in a durable rubber surround with backlit LCD display and in-built Ni-MH battery. See our website or in-store for full specifications.

- 10MHz
- Rechargeable
- CRO probe and USB charge cable supplied
- Size: 114(H) x 74(W) x 29(D)mm

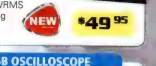
**QC-1914**

Due early Feb

**$249.00**

## RECHARGEABLE TRAVEL SPEAKER

Connect your iPod®, iPhone®, iPad®, Smartphone, MP3 player or computer, or play MP3 or WMA files directly from a USB flash stick or SD memory card. Features include an FM radio, clock and headphone output. Recharge the Li-Ion battery via the USB port of a computer. A full charge provides about 8 hours of listening time.



- Output: 2 x 2.5WRMS
- Size: 217mm long

**XC-5175**

NEW

**$49.95**

## 2 CHANNEL USB OSCILLOSCOPE

A genuinely affordable computer connect oscilloscope. Plug 'n Play USB technology means this oscilloscope is easy to setup and use. The included software includes a chart recorder, function generator, logic generator, logic analyser, and spectrum analyser, all in one easy to use package.

- Oscilloscope: spectrum analyzer
- Sample rate: 100Hz - 200 kHz
- Input voltage -20 to +20V
- ADC capacity: 10 bits

**QC-1930** WAS $299.00

**$179.00**

**SAVE $120.00**

Also available: 40MHz USB Digital Oscilloscope
**QC-1931** WAS $399.00 NOW $279.00 SAVE $120.00

Limited stock. Not available online.

## NEW STORE - MANDURAH WA

**1/78 Pinjarra Rd Mandurah WA**

**Tel: (08) 9586 3827**

**Fax: (08) 9586 2753**

***Parking Available On-site!***

## KEVLAR CAR SPEAKERS

Back by popular demand and with a more competitive price! These are our ever popular Response Precision Kevlar Coaxial Speakers that has won many awards and magazine recommendations. The speaker cone is now supplied in black and tweeters are still the original soft dome tweeter that provides clean, crisp sounds and maintains a natural and smooth balanced sound.

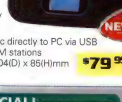
NEW

| | | |
|---|---|---|
| **4" 40WRMS** | **CS-2400** | $69.95 |
| **5" 50WRMS** | **CS-2401** | $79.95 |
| **6.5" 75WRMS** | **CS-2402** | $89.95 |
| **6 x 9" 75WRMS** | **CS-2403** | $119.00 |

**From $69.95**

## CASSETTE PLAYER WITH DIGITAL MP3 ENCODING

Transform your cassette tape collection into digital MP3 format directly via a PC or listen to those old recordings on this multi-function music box. Features cassette playback, high quality amplified speakers, crystal clear AM/FM tuner, blue backlight LCD and alarm clock functions, USB cable and Audacity software included.



NEW

- Play/record music directly to PC via USB
- Store up to 30 FM stations
- Size: 250(W) x 204(D) x 85(H)mm

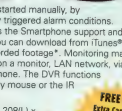
**GE-4140**

**$79.95**

## SUPER SPECIAL!

### Network 4 Channel 10" LCD DVR and Camera Kit

The package incorporates a H.264 DVR with built-in 10" LCD monitor and 320GB HDD, 2 indoor/outdoor CMOS 350TVL colour cameras with IR illumination for night viewing, 2 x 18m cables and power supplies. Recording can be started manually, by programming or by triggered alarm conditions. The main feature is the Smartphone support and the iPhone® app you can download from iTunes® to view live or recorded footage*. Monitoring may be done real-time on a monitor, LAN network, via internet or Smartphone. The DVR functions can be controlled by mouse or the IR remote control.



- DVR/Screen size: 208(L) x 86(W) x 242(H)mm Camera size: 115(L) x 45(H)mm

**QV-3030**

**FREE 2 x Extra Cameras (QC-3239) valued at $119.90**

**$699.00**

*App is free for single use and may incur a charge for multi-user

Prices valid from 24/01/2012 to 23/02/2012. Limited stock on sale items. No rainchecks.

# DIY Tools

## HOBBYIST TOOLS

### 4.8V Cordless Screwdriver

Easy to use cordless and has a comfortable pistol grip that gives you maximum control. It also has a bright LED lamp, a magnetic bit holder, and a handy security strap.

- Voltage: 4.8V
- Bit holder size: 6.35mm
- LED battery level indicator
- Mains charger included

**TD-2498**

$23.95

FREE pouch (TD-2499) with purchase of TD-2498 valued at $5.95

### 125mm Precision Long Nose Pliers

Made from Japan from the same high carbon steel that is used to make professional chef's knives. Feature serrated jaws and a box joint to provide a precise action and strong grip. The coil spring ensures smooth, fatigue-free use.

- Insulated soft touch handles

**TH-1885**

$34.95

Buy 2 for $60.00 SAVE $9.90

### Economy Nibbling Tool

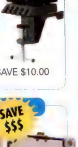
Will cut any shape out of aluminium, plastic, copper and other unhardened metals up to 18 gauge, simply drill a 1/4" hole to start. Designed to fit in the palm of your hand for easy use.

**TH-1768** WAS $19.95

$14.95 SAVE $5.00

## 270° ROTATION CLAMP VICE

The base will clamp to any bench or table up to 55mm thick and the 40mm jaws will take a job up to 58mm in size. Once in position, the head is easily fixed in position with a quick release lever.



- Base size: 115(W) x 94(D)mm

**TH-1769** WAS $39.95

$29.95 SAVE $10.00

Also available: Vacuum Bench Vice

**TH-1766** WAS $29.95 NOW $19.95 SAVE $10.00

## IP66 ABS ENCLOSURES

Gasket seals, stainless steel hardware and IP66 rated for use in industrial, marine and other harsh environments. A size for any application.

- Galvanised chassis

From $9.95

Opaque cover:

**Small** **HB-6400** WAS $16.95 NOW $9.95 SAVE $7.00
**Med.** **HB-6402** WAS $29.95 NOW $19.95 SAVE $10.00
**Large** **HB-6404** WAS $34.95 NOW $29.95 SAVE $5.00

Transparent cover:

**Small** **HB-6410** WAS $18.95 NOW $12.95 SAVE $8.00
**Med.** **HB-6412** WAS $32.95 NOW $27.95 SAVE $5.00

## 21 PIECE STAINLESS STEEL MICRO BIT SET WITH DRIVER

This set contains a collection of stainless steel bits for all repairing jobs such as watch, mobile phones, sunglasses repairs and more. Driver included. See website for full contents.

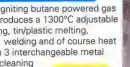
- Case size: 115(L) x 50(W) x 31(D)mm

**TD-2110**

$29.95

## PRO GAS SOLDERING TOOL KIT

A sturdy, portable, self-igniting butane powered gas soldering iron tool kit. Produces a 1300°C adjustable flame for low end brazing, tin/plastic melting, automotive repair work, welding and of course heat shrinking. Supplied with 3 interchangeable metal tips, plastic carry case, cleaning sponge and deflector.

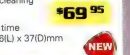


- 80-100 min operating time
- Torch dimensions: 236(L) x 37(D)mm

**TS-1113**

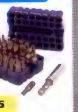
$69.95 NEW

Spare tips & butane gas available separately. See in-store or online for more details.



## POWER DRIVER BIT SET

Comes as a 32 piece set with a magnetic hex driver bit in a plastic-rubber holder/holster. It contains many hard to get bits - especially in the bigger sizes - and really compliments the original set.



- Blue in colour

**TD-2036** WAS $13.95

Limited stock. Not available online.

$4.95 SAVE $9.00

## LCD TYPE ENGINEERS CALIPERS

Features a 5 digit LCD display that will show readings in metric and in imperial measurements. The caliper can be zeroed at any point along the scale making comparative measurements easy. Battery included.

- Auto power off

**TD-2082**

$29.95

## 16 CHANNEL CABLE IDENTIFIER WITH DMM

Ideal for cable installers or technicians and will allow them to easily identify individual conductors in a multi-core cable with just the remote unit attached to the other end. Supplied with remote terminator and multimeter leads.

- Data hold, max hold
- Size: 162(H) x 74(W) x 44(D)mm

**QM-1329** WAS $79.95

$49.95 SAVE $30.00

## GEIGER MULLER TUBE

Detects alpha beta and gamma radiation. The operating range is 450 - 600 volts. It's around 40mm long and 15mm diameter. Schematic diagram for a Geiger counter included.

- 40(L) x 15(Dia.)mm
- Alpha above 3.0 MeV
- Beta above 50 KeV
- Gamma above 7 KeV

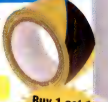
**ZG-6500** WAS $199.00

$99.00 SAVE $100

Limited stock. Not available online.

## HEAVY-DUTY PVC TAPE - 33M

Cordon off hazardous areas or create an unmistakable marker with this heavy duty PVC tape. The vivid yellow and black colouring will draw anyone's attention to the barrier.



- Width: 50mm
- Colour: Yellow/Black

**NM-2866**

$9.95

Buy 1 get 1 FREE

Limited stock. Not available online.

## 6 PIECE INSULATED ELECTRONIC SCREWDRIVER SET

This set contains all the smaller sizes you need for working on electronic gear. They have ergonomic handles with excellent non-slip grips. Storage case included.

- 1000V rated
- Case size: 192(L) x 130(W) x 26(H)mm

**TD-2026**

$19.95

## SOLDERING TOOLS

### 48W Temperature Controlled Soldering Station

Ideal station for the advanced hobby user. Features analogue temperature adjustment, ceramic element and a lightweight pencil that will give you hours of fatigue-free soldering. The stand has spare tip storage and is very sturdy.

- Power: 48W
- Temperature range: 150 - 450°C
- Operating voltage: 24V
- Size: 150(L) x 115(W) x 92(H)mm

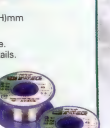
**TS-1564** WAS $99.00

$79.00 SAVE $20.00

Spare pencil and tips available. See in-store or on-line for details.

### Lead-Free Solder

Works just as well as ordinary solder but contains no harmful lead.



- 45g roll with handy cover
- Melts at 243ºC approx

**0.9mm dia.** **NS-3082** $19.95
**1.0mm dia.** **NS-3084** $19.95

$19.95 ea.

Limited stock. Not available online.



All Savings are based on Original RRP. Limited stock on sale items.

# DIY Meters & Testers

## TOOL SETS

### 7 Piece Cr-V Screwdriver Set

Made from an alloy of heat-treated chrome vanadium and molybdenum steel for strength and durability. Made to last. The set contains:

- Slotted: 2.5 x 75, 5 x 75, 5 x 150, 6 x 125mm
- Phillips: #0 x 75, #1 x 75, #2 x 100mm

**TD-2088**

**$8.95**

### 60 Piece Rotary Tool Bit Set

All the bits you need for your rotary tool to grind, polish, cut, sand or clean. All housed in a durable case with transparent lid and carry handle. See website for full contents.

- Case size: 220(L) x 130(W) x 45(D)mm

**TD-2457**

**$9.95**

## 400A AC/DC CLAMPMETER

Easy one-hand operation makes this meter perfect for the working installer or tradesman. A quality, intermediate-level clampmeter with current ranges up to 400 amps AC and DC.

- Cat III 600V
- Data hold, non-contact voltage, relative measurement
- Autoranging
- Auto power off
- Diode test
- Jaw opening 30mm
- Size: 198(H) x 66(W) x 36(D)mm

**QM-1563** WAS $119.00

**$99.00**
SAVE $20.00

## DIGITAL LIGHTMETER

A handy lightmeter for photography, lab work, architectural, engineering and construction. Measure incident light in 4 ranges: 0.01 to 200, 200 to 2,000, 2,000 to 20,000 and 20,000 to 50,000 lux.

- Display: 2000 count
- 3.5 Digit Readout
- Separate Photo Detector
- Size: 188(L) x 64(W) x 24.5(D)mm

**QM-1587**

**$49.95**

## COMPACT DIGITAL SOUND LEVEL METER

Featuring a wide dynamic range from 30 to 130dB, it can measure both A and C weightings to get the right response for the human ear and can have fast or slow responses to get an "ambient" reading or a short noise. Great for car audio installers, clubs and PA. Supplied with carry case and wind sock.

- Data hold and min/max functions
- Display: 3.5 digit
- Size: 210(L) x 55(W) x 32(D)mm

**QM-1589**

**$99.00**

## HAND-HELD ANEMOMETER WITH TRIPOD STAND

A hand held anemometer that measures wind speed in feet/min, MPH, km/h, metres/sec or knots. Measure windchill, air temperature, displays current, maximum and average wind speed. Can be hand held or fixed (stand supplied).

- Wind speed: 0.64 to 107.8km/h
- Size: 115(H) x 45(W) x 16(D)mm less stand

**QM-1644**

**$69.95**

## MOISTURE LEVEL METER

Featuring a simple to use and easy to read display, a bar graph extends up the screen indicating the amount of moisture. Can be used on timber, cardboard, paper, and even on hardened materials.

- Electrode length: 8mm
- Battery: 2 x CR2032 batteries
- Size: 140(H) x 48(W) x 33(D)mm

**QP-2292** WAS $69.95

**$49.95**
SAVE $20.00

## PROBE THERMOMETER

Suitable for lab, chemistry and industrial applications. It measures in Celsius and Fahrenheit and has a stainless steel probe and protective cap. Batteries included.

- Auto power-off
- Low battery indication
- Data hold
- Celsius and Fahrenheit
- Size: 185(L) x 36(W) x 19(H)mm

**QM-7217** WAS $34.95

**$19.95**
SAVE $15.00

## AUTOMOTIVE CHECKS!

### Auto Current Tester

The quick and easy way to measure current in automotive circuits. Simply plugs into blade type fuseholder and displays the current draw on the LCD display.

- 3.5 digit display
- Measurement range: 0 - 20A
- Size: 86(H) x 37(W) x 28(D)mm

**QP-2251** WAS $29.95

Also available: 80A Automotive Blade Fuse Current Meter **QP-2257** $59.00

**$19.95**
SAVE $10.00



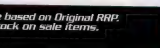
### 12V Battery, Charger and Alternator Tester

A handy device to quickly indicate the condition of your car or truck battery, charger or alternator.

- Compact and lightweight
- Size: 120(L) x 33(W) x 20(D)mm

**QP-2258**

**$12.95**



## DMM CLEARANCE!!!

### Protek 608 True RMS DMM with PC Interface

A DMM with data storage and logging capability suitable for lab, development and testing applications.

- 50,000 count
- RS232C, aux display, auto calibrating
- Low voltage resistance measurement

**QM-1292** WAS $299.00

Limited stock. Not available online.

**$199.00**
SAVE $100

### Inductance/Capacitance/ Frequency DMM

Ideal for audio enthusiasts designing their own crossovers. Supplied with carry case and temperature probe with curly cord.

- 2000 count
- Large CD
- 30-minute auto power-off

**QM-1324** WAS $44.95

Limited stock. Not available online.

**$29.95**
SAVE $15.00

### Dwell Tacho DMM

Features a 3.5 digit LCD with automatic zero adjustment, low battery warning and auto power off after 15 minutes. Includes dwell angle and RPM (x1, x10) for 4, 5, 6 and 8 cylinder engines.

- 2000 count
- Tachometer, dwell angle function
- Dual point distributors

**QM-1440** WAS $39.95

Limited stock. Not available online.

**$29.95**
SAVE $10.00

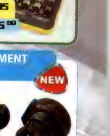
### True RMS Autoranging DMM

Features large 20mm high digits, True RMS measurement, temperature, capacitance, relative measurement, data hold, temperature and more. Includes holster and temperature probe.

**QM-1536**
WAS $79.95

Limited stock. Not available online.

**$34.95**
SAVE $45.00



## LTW IP67 HARSH ENVIRONMENT CIRCULAR CONNECTORS

NEW

Perfect for harsh environments such as marine, industrial, outdoor, automotive, etc. IP67 and UL rated.

- Gold plated
- Solder pins
- 2pin versions rated to 5A
- 4 and 6 pin versions rated to 2A

From **$8.95**

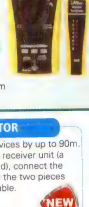
| | |
|---|---|
| 2 Pin Line Socket | PS-0541 $10.95 |
| 2 Pin Panel Mount Plug | PS-0542 $8.95 |
| 4 Pin Line Socket | PS-0543 $12.95 |
| 4 Pin Panel Mount Plug | PS-0544 $10.95 |
| 6 Pin Line Socket | PS-0545 $14.95 |
| 6 Pin Panel Mount Plug | PS-0546 $12.95 |
| Dust Cap to Suit | PS-0547 $6.95 |

# DIY IT

## NETWORKING SOLUTIONS

### 2 in 1 Network Cable Tester and Digital Multimeter

Ideal for network installers or technicians and will allow the user to easily check cable integrity or measure AC & DC voltage, etc without needing to carry two separate devices.



- Case included
- Autoranging
- Display: 2000 count
- Category: Cat III 600V
- Size: 102(H) x 74(W) x 44(D)mm

**XC-5078** WAS $79.95

**$59.95** SAVE $20.00

### 300Mbps Mini 802.11n USB 2.0 Wireless Network Adaptor

Add 802.11n wireless capability to your computer. Supports transfer speeds up to 300Mbps and is part of the 802.11n standard. A secure, sleek and convenient networking upgrade for the home or office.

- Compatible with Windows, Linux and MAC OSX
- Size: 58(L) x 26(W) x 9(H)mm

**YN-8307**

**$29.95**

Also available: 150Mbps Nano 802.11n USB2.0 Wireless Network Adaptor **YN-8308** $19.95

## USB 2.0 EXTENSION ADAPTOR

Extend the range of your USB devices by up to 90m. Connect your USB devices to the receiver unit (a four port USB 2.0 hub can be used), connect the sender to your PC, and finally join the two pieces together with a common CAT5 cable.

- Supports Windows XP, Windows Vista, Windows 7
- Sender and receiver size: 60 x 20 x 30mm

**XC-4923**

**$99.00**

## USB TO DVI ADAPTOR

Enabling the addition of up to six extra displays, this adaptor allows you to add high-resolution graphics without having to add a graphics card - just connect it to any USB 2.0 port.

**XC-4879**

**$79.95**

## 7" USB PLUG AND PLAY LCD MONITOR

Perfect as a secondary monitor that needs its own power and display. Suited for work in the office, you can have a spreadsheet opened on your main display and an email opened in the USB display doing quick and easy data entry. The screen has a nifty little rotatable stand and the display can be adjusted accordingly for portrait or landscape view.

- Screen resolution: WVGA(800 x 480)
- Compatible with Windows
- Size:188(L) x 114(W) 35(H)mm

**QM-3748** WAS $269.00

**$169.00** SAVE $100

Limited stock. Not available online

## TECHY TOOLS

### Computer Cable Travel Kit

Contains over 900mm of pull to extend cable for several PC connections for those just out of range peripherals. Also comes with connectors and 4 way USB hub. See website for full specifications.

**XM-5280** WAS $24.95

**$19.95** SAVE $5.00

### Computer Service Tool Kit

Ideal for computer service technicians or the talented amateur. See website for full contents.

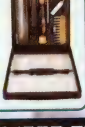
- Black zipper case
- Case size: 220(H) x 155(W) x 38(D)mm

**TD-2040** WAS $29.95

**$19.95** SAVE $10.00

### Gaming Console Tool Kit

Everything you need to get into your gaming console and accessories. Includes tools for pretty much every console and handheld on the market today - Wii®, X-Box®, Playstation® etc. See website for full contents.



- Carry case included

**TD-2109** WAS $29.95

**$24.95** SAVE $5.00

## UPS WITH LCD AND USB

Protect your computer equipment with these robust uninterruptible power supplies. They strike a good balance between real time system protection and power redundancy where mains electricity is down or unreliable. A steady voltage is delivered during voltage sags and in the event of total power blackout your systems will run long enough (10 - 20mins) to shut down cleanly.

Two models available.

**650VA/390W** MP-5205 $179.00

**1500VA/900W** MP-5207 $349.00

**From $179.00**

## USB TO 2 X DB-9 RS-232 CONVERTER

Add two RS-232 based devices to a PC or laptop with this useful converter. Easy to install with plug and play functionality. Will work on USB1.1 and higher. Perfect for GPS devices, cellular phones, barcode scanners, fingerprint scanners and a host of other products.

- Bus-powered (no external power required)
- 2 x DB-9 male serial ports

**XC-4901** WAS $44.95

**$19.95** SAVE $25.00

Limited stock. Not available online

## PLUG & PLAY MPEG-4 IP CAMERAS

These plug & play MPEG-4 IP cameras are loaded with features! Easy to install and they feature resolution of 640 x 480 pixels, have built-in microphone for audio monitoring, and allow you to control up to 16 cameras through the included software. Two models available:

**From $99.00**

**IP Camera**
**QC-3397** WAS $179.00
NOW $99.00 SAVE $80.00

SAVE $80.00

**Wireless IP Camera**
**QC-3399** WAS $229.00
NOW $179.00 SAVE $50.00

## 802.11N PCI-E WIRELESS NETWORK CARD

A simple upgrade for PC motherboards lacking Wi-Fi. Just slot it in a spare PCI-E port for 300Mbps wireless connectivity.

- Complies with wireless 802.11b/g/n standards
- Compatible with Windows and Linux

**YN-8326**

Due early February

**$34.95**

## DC POWER LEAD 2.1MM PLUG AND SOCKET

This range of low voltage power cables is made to run multiple devices such as surveillance cameras from a single power supply or extend the low voltage cable between a plugpack and a device

**Socket to 2 plugs 200mm splitter lead**
**WQ-7280** $7.95

**Socket to 2 plugs 2m splitter lead**
**WQ-7284** $8.95

**Socket to 4 plugs 2m splitter lead**
**WQ-7281** $9.95

**From $7.95**

Also available: 1 socket to 1 plug 5m Extension Lead **WQ-7285** $9.95

## HDMI ADAPTOR

Connect HDMI cables where space is an issue such as wall mounted TV's with this adaptor which swivels up to 180°.

- HDMI plug to HDMI socket
- Gold plated connectors

**PA-3647**

**$12.95**

Also available: Micro HDMI Plug to HDMI Socket Adaptor **PA-3649** $9.95

## ALL-IN-ONE CARD READER WITH 6 SLOTS AND USB HUB

The ultimate card reader! Able to read a multitude of formats, has a flip open top to store micro, SD, XD or any other card of similar size and a two port USB 2.0 hub. The USB cable neatly tucks into the back when not in use.

- Size: 87(L) x 39(W) x 18(H)mm

**XC-4924** WAS $24.95

Limited stock. Not available online

**$9.95** SAVE $15.00



**To order call 1800 022 888**

*All Savings are based on Original RRP. Limited stock on sale items.*

## CCTV POWER SUPPLIES

Mains power supplies suitable for CCTV installations, with multi-channel outputs for each individual camera. Housed in a rugged lockable steel enclosure designed for permanent professional installations. Must be installed by a licensed Electrician.

From **$49.95**
SAVE $20.00

**4 x Separate Channels**
**MP-3850** WAS $69.95 NOW $49.95 SAVE $20.00
**8 x Separate Channels**
**MP-3852** WAS $129.00 NOW $99.00 SAVE $30.00

## HIGH INTENSITY DISCHARGE (HID) SPOTLIGHT

This full-feature unit includes inbuilt rechargeable SLA battery, 240V and 12V charger, dual-LED map light and swing away stand.

- 35W HID bulb
- 30 million candle power
- Size: 280(L) x 190(D) x 140(W)mm (less reflector)

**ST-3379** WAS $99.00

**$69.00**
SAVE $30.00

## MULTIFUNCTION LED LAMP & TORCH

A versatile light source great for reading in the bedroom, shed or on your next BBQ. It also doubles as a detachable hand torch. Adjust light accordingly with the flexible goose neck & clamp onto table tops up to 2.5cm thick.

**$19.95**
SAVE $5.00

- 3 x ultra bright white LED
- Requires 3 x AA batteries
- Torch size: 165(L) x 40(W)mm
- Stand size: 190(H) x 120(W)mm

**ST-3462** WAS $24.95

## DUAL BATTERY CONTROLLER

This unit will charge both your main and auxiliary batteries when the engine is running and automatically isolate the engine battery when you stop. This lets you run fridges & lighting etc. from the auxiliary and preserve the engine battery for starting.

**$89.00**
SAVE $30.00

- 12 - 48 volt operating range
- 70 amp current capacity
- Size 83(W) x 114(L) x 79(H)mm

**MB-3670** WAS $119.00

Limited stock. Not available online

## MAINS POWER ADAPTOR FOR IPAD®/IPHONE®/IPOD®

Mains power adaptor suitable for charging apple products including iPad®.

- Includes 1m USB charging/sync cable
- Output: 5VDC, 2.1A

**MP-3457**

**$19.95** NEW

## 1W LED TORCH WITH IN-BUILT CAR CHARGER

Recharges in your car's cigarette lighter socket. With a robust aluminium alloy housing it can take a fair amount of abuse and still shine as brightly as the day you bought it.

- Size: 160(L) x 35(Dia.)mm

**SL-3381** WAS $19.95

**$9.95**
SAVE $10.00

Limited stock.
Not available online

## RED & GREEN TWINKLE LASER LIGHT DISPLAY WITH BLUE WATERFALL FEATURE

Spectacular lighting effects with hundreds of twinkling and constantly moving laser lights that change with the beat of the music. Also projects a blue LED moving waterfall background. Change directions, speed, rotation and colours.

- Moon star laser show system
- Adjustable mounting bracket
- Brightness adjustment
- Scattering function
- Sizes: 200(L) x 85(W) x 158(H)mm

**SL-3435** WAS $299.00

**$219.00**
SAVE $80.00

Limited stock. Not available online

## IP67 FERRULE CRIMP SOLAR PV CONNECTORS

High quality IP67 waterproof solar PV connectors, featuring IP67 waterproof rating, UV resistant plastics, high current rating and TUV approval. They utilise a ferrule (or closed barrel) type of crimp which ensures a much higher strength crimp. Check our website for suitable crimping tool.

- MC4 compatible

**Socket** **PS-5210** $7.95
**Plug** **PP-5212** $7.95

**$7.95** ea.

NEW

## FOLDING SOLAR CHARGER

This versatile monocrystalline solar charger will fit anywhere, but expand to a full size 10W solar charger. It has a robust nylon fabric enclosure and cigarette lighter socket for powering whatever you need. Two lead sets are included - one with a cigarette lighter plug and another that terminates to alligator clips. Ideal for camping, 4WD, boating, caravans or motorhome holidays.

- Suitable for 12V lead acid batteries
- Open: 750(L) x 220(W)mm Folded: 250(L) x 100(W) x 40(D)mm

**ZM-9120** WAS $179.00

**$149.00**
SAVE $30.00

Limited stock.
Not available online

## 6-WAY SMART POWERBOARD WITH ENERGY METER

One socket never switches off and one 'smart' outlet can be used for main appliance such as your computer. When the main appliance is switched off it will then switch off other related items (i.e printer, scanner etc.). LCD display shows energy consumption. Easy to use and simple to set up.

- Surge protection, overload, spike and noise filtering
- Energy meter with $CO_2$ cal.
- Size: 385(L) x 60(W) x 30(D)mm

**MS-6152**

**$59.95**

## 120W 12VDC 10A DESKTOP STYLE SWITCHMODE POWER SUPPLY

This high current version of our desktop switchmode power supplies is suitable for large surveillance systems and many other applications. Requires an IEC mains lead and optional DC splitter cables (sold separately).

- Output Cable Length: 1.2m
- Size: 174(L) x 72(W) x 44(H)mm

**MP-3241**

**$79.95**

NEW

## MAINS ADAPTOR WITH 2 X USB PORTS

Charge USB devices without wasting a powerpoint. Simply leave it plugged in and still have access for using a mains appliance. Ideal for the business traveller!

- Size: 88(H) x 44(W) x 33(D)mm

**PP-4038**

**$12.95**

NEW

## 38-CHANNEL CB RADIO

Featuring 38 channel UHF transceiver with up to 3km range. Supplied in black units and charging cradle.

- Twin pack
- LED Torch
- Push to Talk (PTT) function
- Electronic volume control
- Scan channel, call tone and monitor functions

**DC-1007** WAS $69.95

**$34.95**
SAVE $35.00

Limited stock. Not available online

## HEADSET FOR CB RADIOS

The air tube on this headset is much lighter than a standard earpiece allowing comfortable use of handheld CB radios for extended periods. Compatible with handheld UHF CB radios with a 3.5mm headset socket.

- Air Tube Length: 250mm

**DC-1031**

**$39.95**

NEW

# DIY Security

## 8-ZONE WIRELESS ALARM KIT

This alarm kit features key fob remote control, backlit LCD control panel with three colour-coded indicators of system status, a PIR sensor and two reed switches. Everything you need to get a basic wireless system set up in your home or office!

Spare sensors are available for you to expand the system as you need. See in-store or website for more info.

- 8 zones
- 4 operation modes
- Low battery indicator
- Back-up battery
- Size: 210(L) x 113(W) x 127(H)mm

**LA-5145**

**$179.00**

**FREE Shed Alarm (LA-5214) Valued at $19.95**

Also available: **Telephone Dialler for LA-5145 Wireless Alarm** NEW

Add this dialler to the LA-5145 (above) and the control panel will automatically dial a series of telephone numbers. Capable of dialling up to 8 telephone numbers.

**LA-5133** $99.00

## 2.4GHZ DIGITAL WIRELESS MINI DVR KITS

Operate on a 2.4GHz DIGITAL band for stable and interference free transmissions, easy setup and operate DIGITAL wireless video recording system suitable for a range of security and monitoring applications. Two models available, both include one wireless DIGTAL motion-sensing colour day/night camera. Both have easy to navigate system settings, and video is recorded to an SD card (not included) which can be played back on a PC or MAC.

QC-3630

- Both systems are expandable up to 4 cameras

**2.4GHz Receiver with Camera QC-3630** $249.00

**2.4GHz Receiver with Camera and 7" LCD Monitor QC-3632** $349.00

**From $249.00**

Spare cameras sold separately:

**Night Vision Camera QC-3634** $149.00

**Solar Powered Camera QC-3633** $219.00

## PROFESSIONAL CAMERA & LENSES

### Hi-Res Colour CCD Camera - Pro Style

High Resolution colour CCD-equipped camera to dramatically improve low-light performance.

- High Resolution Sony HR SuperHAD sensor
- High performance in low light levels
- 520 TV lines
- Size: 118(L) x 62(W) x 50(H)mm

**QC-3307** WAS $299.00

**$129.00** SAVE $170

Also available: Hi-Res Day/Night Colour CCD Camera **QC-3301** $129.00

Limited stock. Not available online

### C Mount Lenses

These high quality C mount lenses have been carefully selected to match most professional cameras.

- Manufactured in Korea

**4mm QC-3315** WAS $24.95 NOW $9.95 SAVE $15.00

**6mm QC-3316** WAS $24.95 NOW $9.95 SAVE $15.00

Limited stock. Not available online

**$9.95 ea.**

## 7" LCD MONITOR SURVEILLANCE KIT

Simple, cost-effective surveillance solution for small scale indoor applications such as shops and small offices. Powered from one plugpack, all power and video is run along a single integrated cable. Kit contains: 7" LCD monitor, 2 x CMOS colour cameras, 2 x 18m cables, mains adaptor, remote control and mounting brackets.

- Camera resolution: 420TV Lines
- Monitor resolution: 480 x 234
- Camera size: 85(L) x 46(Dia.)mm
- Monitor size: 186(W) x 86(H) x 30(D)mm

**QC-3640** WAS $199.00

**$149.00** SAVE $50.00

## B&W VIDEO DOOR PHONE

This modern, slimline video intercom system will let you identify callers without them even knowing. The system consists of a black and white CMOS camera with speaker and microphone and internal monitor with handset.

- Built-in IR illumination
- Intercom also doubles as a doorbell
- Works with our remote door release - **LA-5078** $49.95

**QC-3602** WAS $129.00

Extra receiver also available **QC-3603** $59.00

Limited stock. Not available online

**$79.00** SAVE $50.00

## 2.5" LCD ELECTRONIC DOOR PEEP HOLE VIEWER

With its 2.5" LCD screen and a built-in distortion compensation feature, you can see the person clearly on the other side of the door by a simple press of a button. The camera is no bigger than an original fisheye viewer and looks the same as a peep hole viewer from the outside. Simple to install without compromising door security. Comes complete with an installation tool and AA batteries.

- Size: 146(W) x 90(H) x 30(D)mm

**QC-3267** WAS $199.00

**$129.00** SAVE $70.00

## ILLUMINATE YOUR DRIVEWAY!

Perfect to illuminate your outdoor areas where mains power is unavailable. These high powered CREE® LED sensor lights provide a bright focused beam of light to illuminate your driveway, entry way or backyard.

### Battery Powered 2W LED Sensor Light

This 2W CREE® LED sensor light easily mounts to any outdoor area and it will give you up to 180 degrees of motion detection. The angle of the light and PIR detector are fully adjustable. Using 4 x C size batteries (not included) you can get up to 110 days of use* before needing to change the batteries.

**SL-2711** WAS $49.95

* Based on 20 seconds of light, 15 times per day using an alkaline battery

**$44.95** SAVE $5.00

### Solar Powered 3W LED Sensor Lights

A fully self sustained lighting kit without the use of mains electricity. A waterproof solar panel with a 5m lead is supplied to keep the rechargeable batteries topped up. Two models available: 1 x 3W and 2 x 3W. Each unit has a built-in PIR motion detector, which automatically turns the light on from an adjustable period of 5 to 20 seconds.

- Adjustable swivel head

**3W CREE® SL-2707** WAS $99.00 NOW $79.00 SAVE $20

**2 x 3W CREE® SL-2709** WAS $129.00 NOW $109.00 SAVE $20

**From $79.00** SAVE $20.00

## DUMMY IR CAMERA KIT WITH FLASHING SIGN

This dummy IR camera kit comes with two dummy IR cameras, CCTV flashing sign and 2 x CCTV sticker. The cameras have genuine looking IR LEDs and a real LED that adds to the illusion. The CCTV flashing sign is solar powered and can be changed to not flash by covering the solar panels on the side.

- Requires 2 x AA batteries
- Mounting hardware included
- Camera Dimensions: 175(L) x 85(Dia)mm
- Flashing Sign Dimensions: 51(L) x 10(W) x 50(H)mm

**LA-5329**

**$49.95**

## CHILD MONITOR SURVEILLANCE SYSTEM

Keep an eye on a room full of children and pan across to zoom onto any one of them, or monitor swimming pool, retail showroom, or factory. You can remotely pan or tilt the camera or even zoom in for a closer look.

- 2.4GHz DIGITAL Wireless transmission
- 100m transmission range
- 2.4" LCD monitor screen
- CMOS image sensor (640 x 480 pixels)
- Camera pans 270°, tilts 120°.
- 2 times digital zoom
- 4 separate channels
- Includes power adaptor for both units
- Camera size: 112(W) x 109(D) x 133(H)mm
- Monitor size: 68(W) x 26(D) x 149(L)mm

**QC-3638** WAS $299.00

Spare 2.4GHz PTZ DIGITAL Camera available separately **QC-3637** $199.00

**$279.00** SAVE $20.00

## 3-AXIS COLOUR DOME CAMERAS

3-axis mechanism provides easy installation and enables you to put the camera's field of view exactly where required. Quality Sony sensors and optics, models include high resolution 550TVL and economical 380TVL.

- Size: 110(Dia.) x 85(H)mm

**380TVL QC-8616** WAS $99.00 NOW $79.00 SAVE $20.00

**550TVL QC-8617** WAS $199.00 NOW $149.00 SAVE $50.00

**From $79.00** SAVE $20.00



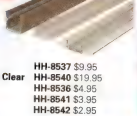
All Savings are based on Original RRP. Limited stock on sale items.

# DIY Lighting

## EXTRUDED ALUMINIUM CHANNEL FOR LED STRIPS

Designed for mounting and protecting 8-12mm wide LED strips. Ideal for architectural light fixtures, caravan, outdoor use and protection whilst camping. Mount it behind skirting board to create light effects on a wall, or install in a display cabinet to provide a directed ribbon of light on your valued items.

NEW



**$9.95**

- Size: 1030(L) x 14(W) x 14(H)mm
- LED strips sold separately
- 1m diffuser strips available separately
- Slide-in diffuser evens out the light

**Extruded Channel** **HH-8535** $9.95

Also available:

| | |
|---|---|
| **Diffuser Insert Strip** | **HH-8537** $9.95 |
| **Diffuser Insert Flanged Clear** | **HH-8540** $19.95 |
| **Channel Endcap Pk2** | **HH-8536** $4.95 |
| **Diffuser Endcap Pk2** | **HH-8541** $3.95 |
| **Clip Mount Pk2** | **HH-8542** $2.95 |

## 12V 500mA SOLID LED LIGHT STRIPS

An efficient, bright and affordable LED lighting solution, which is safe and easy to install. Each strip features wide angle, high brightness SMD LEDs and are powered by 12VDC. They are fixed easily using the strong 3M brand self adhesive backing tape or mounted into a range of aluminium and plastic extrusions and diffusers available separately.

NEW

**$34.95** ea.

**White 390 Lumens**
**ZD-0552** $34.95
**Warm White 340 Lumens**
**ZD-0550** $34.95

## 50 LED LIGHT BAR WITH DIFFUSER

Containing a 50 LED strip housed in an aluminium case and covered with an acrylic diffuser, this light bar provides a fully formed LED lighting solution.

NEW

**$44.95**

- Voltage: 12VDC
- Current: 500mA
- 240 lumens, cool white
- Size: 520(L) x 11(W) x 14(H)mm

**ZD-0489**

## MR11 CREE® LED DOWNLIGHT

Often used for caravan lighting and in reading lights, MR11 is slightly smaller than MR16. Aluminium housing ensures adequate heat dissipation from the high power CREE® LED inside.

NEW

- Each uses one CREE® XP-E LED driven at 2.6W
- MR11 housing and base
- Best if powered by linear AC downlight transformer or 12VDC supply
- Equivalent to a 10-15W halogen globe

| | | |
|---|---|---|
| **White** | **ZD-0341** | $19.95 |
| **Warm White** | **ZD-0343** | $19.95 |

**$19.95** ea.

## GU10 LED DOWNLIGHT KITS

Simply cut a hole and drop them in. Mains powered and dimmable with normal dimmers, so no additional power supplies, transformers or ballasts required. Each assembly includes a junction box and spring clips to mount to any surface up to 25mm thick. White or warm white, in singles or packs of four.

NEW

- 3 x 2W CREE® GU10 LED

**From $54.95**

Due late February

| | |
|---|---|
| **White** | **ST-3896** $54.95 |
| **Warm White** | **ST-3897** $54.95 |
| **White Pk4** | **ST-3898** $179.00 |
| **Warm White Pk4** | **ST-3899** $179.00 |

## 3 PIECE LED PUCK LIGHT KIT

With 3 x 1W in each of the 3 lights; they can be surface mounted or recessed to fit into your décor. Powered by a single plugpack with a distribution block on a 2m cable.

- Low power consumption
- Cool white colour
- More than 30,000 hours life
- Power supply 12VDC 1A
- Light size: 72(Dia) x 28(H)mm

**ST-3894** WAS $119.00

**$79.00**
SAVE $40.00

## 8 LED UTILITY LIGHT

Constructed in a U shaped bracket, this utility LED is light enough to hang from your wall or bedpost without trailing wires. Perfect as a reading light or for an easy way to highlight your favourite wall painting.

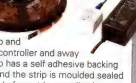
**$11.95**
SAVE $3.00

- Requires 3 x AA batteries
- Wall mounting brackets included
- Size: 190(H) x 330(W) x 150(Dia.)mm

**ST-3189** WAS $19.95

## RGB LED FLEXIBLE STRIP LIGHTING KIT - 12VDC

Everything you will need to set up your own colour changing strip lighting system. Simply connect the LED strip and power supply to the controller and away you go. The LED Strip has a self adhesive backing for easy installation and the strip is moulded sealed which makes it suitable for outdoor applications. The remote control allows you to select from various colour changing modes or fixed colour modes.



- LEDs per metre: 30
- Includes: 5m RGB flexible strip, LED panel controller and 12VDC power supply

**SL-3958**

**$149.00**

## 2 X 300MM CCFL LIGHTING KIT

These flickerless cold cathode fluorescent (CCFL) tubes produce an astounding amount of light for their tiny size of just 11mm dia. Encased in a clear tube, desgined for mounting inside a computer tower case but can also be used for show cars, illuminating signs, cabinets, fish tanks etc. Supplied as a pair and come complete with pre-wired switch and inverter.

- 12VDC

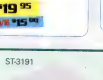
Three colours available.

| | | |
|---|---|---|
| **White** | **SL-2855** | WAS $22.95 |
| NOW $14.95 SAVE $8.00 | | |
| **Blue** | **SL-2856** | WAS $22.95 |
| NOW $14.95 SAVE $8.00 | | |
| **UV** | **SL-2857** | WAS $22.95 |
| NOW $14.95 SAVE $8.00 | | |

**$14.95**
SAVE $8.00

## 12VDC FLEXIBLE 21 LED LIGHTS BLUE

Not just a typical LED light mounted on a PCB and inside a clear acrylic tube, this ones is FLEXIBLE! Can be mounted straight but will easily bend end-to-end, giving you a myriad of mounting options. This unit will create a great glow in your car.



- 21 LEDs
- 610mm long tube

**SL-3952** WAS $34.95

**$19.95**
SAVE $15.00

## BATTERY OPERATED LIGHTING

### 1W LED Light with Swivel bracket

Very handy, great for dark cupboards, garages or hard to reach areas. Simply place on a shelf or mount on a wall, and switch on. No mains power required.

- Requires 3 x AA batteries
- Swivels up to 330°
- Size: 90(H) x 87(Dia.)mm

**ST-3187** WAS $19.95

**$11.95**
SAVE $8.00

**2 for $20.00**

### Cabinet LED Lights

ST-3191

A perfect lighting solution for cupboards, shelves and drawers! These compact battery operated LED lights are mounted flush inside and will automatically turn on when the door or drawers are open. Low power consumption and has long LED life.

ST-3192

**4 LED ST-3191** WAS $14.95
NOW $9.95 SAVE $5.00
**7 LED ST-3192** WAS $24.95
NOW $11.95 SAVE $13.00

**From $9.95**
SAVE $5.00

### Rite Light

**2 for $10.00**

Simple one touch operation and super bright LEDs make this the most versatile and easy to install light you'll ever purchase. No need for cords or plugs.

- Requires 3 x AAA batteries
- 5 LEDs
- Size: 90(Dia.)mm

**ST-3165**

**$6.95**

# DIY Project Kits

## KIT OF THE MONTH

**Ultrasonic Antifouling for Boats**

Marine growth electronic antifouling systems can cost thousands. This project uses the same ultrasonic waveforms and virtually identical ultrasonic transducers mounted in a sturdy polyurethane housing. By building it yourself (which includes some potting) you save a fortune! Standard unit consists of control electronic kit and case, ultrasonic transducer, potting and gluing components and housings. The single transducer design of this kit is suitable for boats up to 10m (32ft); boats longer than about 14m will need two transducers and drivers. Basically all parts supplied in the project kit including wiring.

- 12VDC
- Suitable for power or sail
- Could be powered by a solar panel/wind generator
- PCB: 78 x 104mm

**KC-5498**

**$249.00**

## SOLDERING IRON STARTER KIT

All the soldering essentials for the hobbyist. This kit represents excellent value, the best in soldering we've seen, anywhere. The sum of the individual parts amount to more than double the price we are selling this kit for. See in-store or on-line for full contents.

- 20/130W

**TS-1651**

**$24.95**

## DAB+/FM DIGITAL RADIO KIT

Many Hi-Fi enthusiests want to add a digital tuner to their system and want great function and sound quality. This unit covers DAB+ and FM, has analogue and optical audio outputs, IR remote (included), an external antenna connector and is powered by mains plugpack. The kit is complete with everything, including the case. See website for full specs.

- Digital station info display
- RCA and optical audio output
- External antenna connection
- Station memory presets
- 9VAC plugpack inlcuded

**KC-5491** WAS $399.00

**$299.00**
**SAVE $100**

## ADVANCED CAR ALARM WITH PIN CODE FUNCTION

A full featured alarm with code hopping remotes that feature PIN code security so a would-be thief can't get into your car even if they have the remote. Also includes a two stage shock sensor, door and boot triggers, a 125dB siren, and a microwave movement sensor.

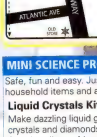
- Ignition cutout relay
- Battery backup siren

**LA-9008** WAS $129.00

Also available: Spare remote **LA-9009** $39.95

**$99.00**
**SAVE $30.00**

## GOLD COAST STORE RELOCATION




**2574 Gold Coast Hwy Mermaid Beach Qld 4218**

**Ph: (07) 5526-6722**

***Parking Available!***

## MINI SCIENCE PROJECT KITS

Safe, fun and easy. Just add a couple of common household items and away you go.

**Liquid Crystals Kit**

Make dazzling liquid gems, crystals and diamonds. Surprise all your friends creating fake ice or an invisible gem.

**KJ-8930**

**$9.95**

Limited stock. Not available online

**Slime Shop Kit**

Gross everyone out with your own snotty slime. Follow the instructions to make your own disgusting slime creation.

**KJ-8932**

**$9.95**

Limited stock. Not available online

## 5-SECTOR ALARM PANEL WITH DIALLER

AV-GAD Alarm Panels are big on features yet surprisingly affordable. The panels feature DTMF support which enables you to get access to the alarm panel from a telephone keypad anywhere in the world - effectively being a long range remote control of your alarm panel. Supplied with detailed user manual, installation manual and AV702TP keypad (with in-built tamper switch).

- Built-in dialler (with DTMF control)
- Fully programmable using the keypad or via RS-232 interface with the optional cable

**LA-5500** WAS $299.00

**$239.00**
**SAVE $60.00**

Limited stock. Not available online

Also available: Spare keypad **LA-5518** $169.00

## DVR KIT WITH 4-COLOUR CAMERAS

Suited to smaller surveillance installations around the home or office. This four channel system can store over 150 hours of video on the 320GB HDD. Recorded video is indexed in an event log and can be viewed via a computer or external monitor. Complete with four weather resistant IR cameras, cables, remote control and mains adaptor.

**$349.00**
**SAVE $250**

- MJPEG compression
- SATA hard drive interface
- CMOS sensor, 350TV Lines
- Built-in infrared illumination

**QV-3024** WAS $599.00

Limited stock. Not available online

Also available: 4 Channel DVR Kit H.264, 500GB HDD with 4 Outdoor Cameras **QV-3026** WAS $599.00 $399.00 SAVE $200.00

## Solar Powered Rowing Boat Kit

Easy to build boat and use a solar panel to drive the rowing mechanism. Suitable for ages 8+

- Approx. 210(L) x 400(W)mm

**KJ-8922**

**$9.95**

Limited stock. Not available online

# YOUR LOCAL JAYCAR STORE - Free Call Orders: 1800 022 888

**• AUSTRALIAN CAPITAL TERRITORY**

Belconnen Ph: (02) 6253 5700
Fyshwick Ph: (02) 6239 1801

**• NEW SOUTH WALES**

Albury Ph: (02) 6021 6788
Alexandria Ph: (02) 9699 4699
Bankstown Ph: (02) 9709 2822
Blacktown Ph: (02) 9678 9669
Bondi Junction Ph: (02) 9369 3899
Brookvale Ph: (02) 9905 4130
Campbelltown Ph: (02) 4620 7155
Castle Hill Ph: (02) 9634 4470
Coffs Harbour Ph: (02) 6651 5238
Croydon Ph: (02) 9799 0402
Erina Ph: (02) 4365 3433
Gore Hill Ph: (02) 9439 4799
Hornsby Ph: (02) 9476 6021
Liverpool Ph: (02) 9821 3100
Maitland Ph: (02) 4934 4911
Newcastle Ph: (02) 4965 3799
Penrith Ph: (02) 4721 8337
Port Macquarie Ph: (02) 6581 4476
Rydalmere Ph: (02) 8832 3100
Sydney City Ph: (02) 9267 1614
Taren Point Ph: (02) 9531 7033
Tweed Heads Ph: (02) 5524 6566
Wagga Wagga Ph: (02) 6931 9333
Wollongong Ph: (02) 4226 7089

**• NORTHERN TERRITORY**

Darwin Ph: (08) 8948 4043

**• QUEENSLAND**

Aspley Ph: (07) 3863 0099
Caboolture Ph: (07) 5432 3152
Cairns Ph: (07) 4041 6747
Capalaba Ph: (07) 3245 2014
Ph: (07) 3282 5800
Ph: (07) 5537 4295
Mackay Ph: (07) 4953 0611
Maroochydore Ph: (07) 5479 3511
Mermaid Beach Ph: (07) 5526 6722
Nth Rockhampton Ph: (07) 4926 4155
Townsville Ph: (07) 4772 5022
Underwood Ph: (07) 3841 4888
Woolloongabba Ph: (07) 3393 0777

**• SOUTH AUSTRALIA**

Adelaide Ph: (08) 8231 7355
Clovelly Park Ph: (08) 8276 6901
Gepps Cross Ph: (08) 8262 3200
Reynella Ph: (08) 8387 3847

**• TASMANIA**

Hobart Ph: (03) 6272 9955
Launceston Ph: (03) 6334 2777

**• VICTORIA**

Cheltenham Ph: (03) 9585 5011
Coburg Ph: (03) 9384 1811
Frankston Ph: (03) 9781 4100
Geelong Ph: (03) 5221 5800
Hallam Ph: (03) 9796 4577
Kew East Ph: (03) 9859 6188
Melbourne Ph: (03) 9663 2030
Ringwood Ph: (03) 9870 9053
Shepparton Ph: (03) 5822 4037
Springvale Ph: (03) 9547 1022
Sunshine Ph: (03) 9310 8066
Thomastown Ph: (03) 9465 3333
Werribee Ph: (03) 9741 8951

**• WESTERN AUSTRALIA**

Joondalup Ph: (08) 9301 0916
Maddington Ph: (08) 9493 4300
Mandurah **NEW** Ph: (08) 9586 3827
Midland Ph: (08) 9250 8200
Northbridge Ph: (08) 9328 8252
Rockingham Ph: (08) 9592 9000

Arrival dates of new products in this flyer were confirmed at the time of print. Occasionally these dates change unexpectedly. Please ring your local store to check stock details. **Prices valid from 24th January to 23rd February 2012.** All savings are based on original RRP

**Head Office**
320 Victoria Road, Rydalmere NSW 2116
Ph: (02) 8832 3100 Fax: (02) 8832 3169

**Online Orders**
Website: www.jaycar.com.au
Email: techstore@jaycar.com.au

Jaycar Electronics
Better, More Technical

# PRODUCT SHOWCASE

## Soanar anti-fouling unit – for big boats!

SILICON CHIP readers will recall the Ultrasonic Anti-Fouling system published in the September and November 2010 issues. It works by vibrating the hull of the vessel (outside human hearing range) but creating a very hostile environment for marine growth.

Users report outstanding results, saving big money by not requiring slipping and toxic anti-fouling paints.

Much of the development work for that system was undertaken in conjunction with Jaycar Electronics. Now a 4-channel commercial version has now been designed and manufactured for larger vessels and for those who do not wish to build the kit (which Jaycar still stocks).

With commercial anti-fouling systems normally costing anywhere up to $8000 (plus installation), this dual-channel (ie, two transducers) install-yourself system is an absolute steal at just $899.00!

The system comes completely built and tested, ready for installation in any aluminium or non-foam fibreglass craft up to about 14m (larger boats, up to 20m, will need the quad transducer system also available from Jaycar). For even larger boats, multiple units can be installed.

Much more information on the Soanar Ultrasonic Antifouling system is available from the Jaycar Electronics website (Cat No YS-5600).

Contact:
**Jaycar Electronics** (all stores)
PO Box 107, Rydalmere NSW 2116
Order Tel: 1800 022 888 Fax: (02) 8832 3188
Website: **www.jaycar.com.au**

## Freescale Kinetis Cortex-M4 MCUs in Stock at Mouser

Mouser Electronics is stocking the Freescale Semiconductor 32-bit Kinetis Cortex-M4 microcontroller family. Freescale is one of the first companies to introduce production M4 products.

The ARM Cortex-M4 processor is the latest embedded processor by ARM specifically developed to address digital signal control markets that demand an efficient, easy-to-use blend of control and signal processing capabilities. Combined high-performance, low-power and low-cost, the Cortex-M4 family is ideal for the motor control, automotive, power management, embedded audio and industrial automation markets.

The Kinetis product line consists of five MCU families with more than 200 pin, peripheral and software-compatible devices with outstanding performance and feature scalability. Also available is a suite of development tools, including controller boards for Freescale's Tower System and evaluation kits, as well as software tools from Keil and Micrium to enable rapid development of new Cortex M4-based systems.

To learn more, visit **www.mouser.com/freescalekinetis/**

## Plessey's EPIC sensor 'product of the year 2011'

Plessey Semiconductors has received US trade publication *Electronic Products* 'Product of the Year' award for its EPIC PS25X01 electric potential sensors. Thousands of products were evaluated.

The EPIC sensor measures changes in an electric field in the same way that a magnetometer detects changes in a magnetic field.

It will enable innovative products to be made such as medical scanners that are simply held close to a patient's chest to obtain a detailed ECG reading.

It could enable devices that can 'see' through walls, control artificial limbs from a simple pad on the skin's surface and detect eye muscle movements for new human-machine interfaces, all without the need to implant electrodes. The sensor's ability to detect movement over distances ranging from a few centimetres to several metres enables applications in security systems and for proximity control of lighting and other electric appliances.

The winners are listed in the January 2012 issue of Electronic Products and also appear on the website **www2.electronicproducts.com/productyear.aspx**

## 50 Years of Vintage Radio collecting up for auction

Under instructions from Garfield Wells, the former secretary of the Historical Radio Society, a substantial collection of over 200 pieces, representing over 50 years of collecting, will be offered by auctioneers Raffan, Kelaher & Thomas in their rooms at 42-48 John Street Leichhardt NSW on Sunday, 26th February at 12 noon.

The collection has many highlights, including rare coloured Bakelites, Art Deco plastics, Neon radios from the 60s, Empire States, Cathedrals, Tombstones, Breadboards, Coffins, rare valves, and an interesting collection of horn speakers. Included is the first horn used in the Odeon cinema, when talkies arrived. There's a Radiola III with working WD11s and a rare, all-original 1922 Coherer 3-valve set presented to George Fisk, the first CEO of AWA by the founding Telefunken principals who formed the AWA corporation in Australia. Also featured is a working Telefunken 'Jewel box', with original Telefunken valves, plus RCA, Atwater Kent, Radiolas and a complete 13 volume set of the entire US valve radio schematics.

For further information contact Garfield Wells on 0405 252 644, or contact Phillip Thomas (02) 9552 1899 (RK&T auctioneers) for a pre-sale catalogue.

Bids by phone & internet are available.

# SERVICEMAN'S LOG

## You've got to have a good system in place

Dave Thompson*

**Servicing computers is usually straightforward. It's the customers that create the problems, with a seemingly endless array of misunderstandings and sometimes outright "try-ons". Having a good system in place is the only way to avoid such problems and ensure a profitable business.**

### Items Covered This Month

- You've got to have a system
- Doppler VOR fault
- Intermittent TV repair
- A mouse in the house

*Dave Thompson, runs PC Anytime in Christchurch, NZ.

It's been my policy to ensure that my stories in Serviceman's Log are not too "computer-centric", which may seem odd since my days are mainly filled servicing computers. However, I adopted this approach because unless you are specifically interested in computers, it is probably the most boring service field known to humankind.

With plumbing or washing machine repair, you at least get smudges on your overalls and dirt under your fingernails to indicate that something has been accomplished. You might even have to remove the odd foreign object from workings or pipes. Whether urban legend or not, we hear no end of tales of appliance repair people finding deceased rodents or other wildlife bunging up the works, all of which equates to excitement and variety for the person doing the job.

It's different servicing computers. Apart from the extremely rare instances of a mouse or a snake (well, perhaps not in NZ) inside a computer box, computer repair is typically mind-numbingly mundane and trying to dress it up any other way is a waste of time. In fact, the only thing most people outside the business want to know about computer repair is do we ever find any porn on clients' drives (the answer is yes, by the way).

The biggest problem with computer repairs is customer relations – in particular, who is responsible for any remedial work that may be necessary. Take car panel repairs as an example – you get a dent removed, the tin-basher does a great job, you pay him and off you go. Now consider what happens if, later that day, someone in the local supermarket carpark backs into you, creating another dent. You certainly can't go back to the panel shop and tell them the dent has come back and that they should fix it all over again for nothing.

And yet, this type of situation all too frequently happens to computer repair people.

No, I'm not talking about us fixing dents in cars (though given the quakes and the current economic climate, give us a call and we'll see what we can do!). No – with us, it's the scenario where we fix something and within days (or sometimes just hours) the client is back complaining of "the same problem".

A GOOD ACCOUNTING SYSTEM IS VITAL

The problem here is that even if it is a different problem, the client believes it to be the same problem. That's a problem for us because it usually is a completely different problem and not the same problem at all. But because they claim it is the same problem, it then becomes our problem, regardless of the original problem.

My apologies if I'm starting to sound like Sir Humphrey Appleby but . . . well, you get my drift.

The easiest way to illustrate this, er, problem, is with virus removal. We get an infected machine in, remove the virus and return what we know to be a totally "cleaned-out" machine only to have the client return the very next day and claim that we haven't done a very good job because the virus is still there. The attitude is invariably the same – we're sorry excuses for "technicians", we have ripped off the client by charging for doing nothing and any further remedial work must be done free of charge.

Now there are only two viable scenarios here: (1) we actually didn't do a very good job of removing the virus and the machine is still infected; or (2) we did remove the virus and the client has simply revisited the same porn or warez website as before or has downloaded and run the same dodgy program or email attachment and re-infected the machine.

Believe me, it's the second scenario that's invariably the correct one. I've been in the industry for 15 years now and do know something when it comes to defeating virus infections and removing them without destroying everything else on the hard drive.

It usually isn't hard to prove that any subsequent infection has happened after the machine has left our care but explaining this to a by now somewhat hostile client is usually difficult and fraught with, well, problems.

So that's the difficulty we face with virus infections. Now let's consider another typical computer-repair issue. Let's say that a faulty machine comes in for service. We repair the fault, give it a clean bill of health and then two weeks later the hard drive suddenly fails. The client – quite rightly in their mind – then questions why we didn't pick up on the fact the hard drive was failing when we had the machine on the bench. We are then expected to do whatever data recovery and any other remedial work the client deems is our responsibility, all without charge because we were somehow negligent – or so goes the reasoning!

Pleading the case that this type of thing happens and that any electro-mechanical device, from your microwave oven to your mobile phone, could do the same thing at any time doesn't seem to cut it with some clients. Indeed, that line certainly didn't work when I tried it with my local mechanic after my van engine coincidentally failed less than a week after they'd serviced it. In that case, I had to fork out huge amounts of money to have it repaired because they doggedly denied any and all responsibility and the onus was on me to prove otherwise.

They were right of course; I couldn't prove that it was their fault or that they had been negligent. Similarly, you could hardly hold the mechanic responsible if he replaced a water pump one week and the clutch failed the next – the two faults are unrelated. However, for some reason it appears to be acceptable practice for clients to try it on with computer repair people, the big difference being how we deal with it.

Given these examples, how does one walk the customer-relations minefield and emerge with the company's reputation and the client's continued custom intact? There are only three possibilities, all of which could end up with the client defecting to your competition and bad-mouthing your service anyway: (1) you either fob the client off with an indignant reproach for suggesting your service is sub-par and/or charge them again for any further work (the car mechanic approach); (2) you do your best to educate the client about the vagaries of computer repair while trying to come to some reasonable compromise; or (3) you meekly surrender and repair the whole thing for free and put the whole situation down to "experience".

THE BIGGEST PROBLEM WITH COMPUTER REPAIRS IS CUSTOMER RELATIONS

None of these scenarios is something any technician wants to deal with and over the years, I have found that the best way of avoiding customer problems is by having decent internal procedures in place. In other words, an ounce of protection is better than constantly being done over by clients who don't know any better or who all to often don't want to know.

It's a fact of life; if you fix computers for a living, you have to take precautions. Bolting the door afterwards is far too late and if you don't watch out, you'll end up doing half your repair work twice and (likely) for free.

Now I'm not saying that most clients deliberately set out to "try it on" in this manner (though undoubtedly there are some who do). Instead, it's mainly due to a lack of understanding as to how the technology works.

My approach is to try to prevent such misunderstandings from occurring in the first place. How? Simple – by demonstrating to the client that the problem has been dealt with completely and that the machine is fully serviceable when they come to collect it; something that I get them to sign off on.

This morally and legally implies that any further problems must have come about after the machine has left the workshop. It also implies that any further work can be legitimately charged for without any recent (or even historic) repair history being brought into the equation, provided that this history can be reasonably discounted.

Now although having such a system in place greatly reduces the problem of us having to do free remedial work on faults not of our making, everything must still be done in a professional, legal and tactful way. In particular, it's important that a client understands and accepts the situation and, more importantly, is happy with it.

As any small-business owner will tell you, repeat business is what keeps kids in shoes and beer in fridges. Customer relations are important and we don't want to implement such a bulletproof system that it ends up simply pinging customers off to the competition.

In fact, business mentors take great pains to remind us that it takes a lot

more time and effort to gain a client than it does to keep one, so it makes sense to try to hold onto those we have. And that sometimes means treading a very fine line between appeasing clients or standing firm and asserting that any current damage must have occurred after the machine left our workshop and any further work must be paid for.

This is something that can only be achieved with the right pre-emptive systems already in place. Not that this relates solely to the computer repair business; strong internal systems are the backbone of every business, from Microsoft to the local corner dairy, which I believe is mysteriously called a "milk-bar" in Australia (Editor's note: a dairy in Australia is a place where we keep cows).

The approach to customers usually comes down to the personality of the business owner. There are basically two types in business: (1) those who will go for the "one big bite" and don't care about the client once they have walked out the door; and (2) those who take the "soft-sell" approach and look after clients so that they keep returning for the life of the business

The former type operates best in large cities where reputations are easier to mask and the potential client base is huge and expanding quickly enough for them to get away with dodgy practices – at least, until the word gets around. They will tend to add spurious extra charges to the bill and utilise any other dodgy methods of leeching as much possible profit out of each individual sale or job, not caring if the client returns or not.

If you have been around the block a few times, you'll likely recognise companies run by people like this.

The second type of business person works best in both large and small towns, looking after clients, sometimes helping them at no cost, charging sensibly and using goodwill as an effective marketing tool.

It would be nice to think that the latter model is more successful but in the real world, it's often the "sharks" that live in the big houses and drive the flash cars. Unfortunately, being a good serviceman doesn't necessarily qualify one to be a good businessman (and vice versa) but the two can be successfully combined if you work at it.

In the end, it all comes down to this: if keeping customers is important, any remedial work is something that must be negotiated and handled with great care. Often, it must be done at a discount in order to placate the customer but the ultimate conclusion may not be your choice anyway; the client may have already made up their own minds not to return, even after the apparently "shoddy" work has been put right.

That's the fine line all service people walk. It is extremely difficult to appease angry clients and retain them, which is why the business mentors will stress that the best possible practice is to not make them angry in the first place. However, that's a lot easier said than done; some people are just too unreasonable to deal with.

A good accounting system is vital. Invoicing and requiring payment on completion of work can make the difference between a viable business and a struggling one. Small businesses are not banks; they need cash flow, so why do so many lend money to clients by allowing them to get away with paying sometimes months down the track?

I initially struggled with this because of my easy-going "she'll be right" nature. However, I quickly learnt that chasing down outstanding accounts was very time-consuming and that some clients could be very reluctant to pay up. And sometimes, within the 90 days it took others to pay, they'd do something silly or something else would go wrong and I would then have to do free remedial work just to get paid for the original fault!

Invoicing at the time of the job and enforcing payment on completion (before the client gets their hardware back or we leave an on-site workplace) immediately turned things around and got cash flowing in the right direction. Of course, it's necessary to spell all this out to the client when the job is booked, so that there are no misunderstandings.

So the other critical system for us was implementing a comprehensive job sheet. This entails testing the machine in reception with the client standing there while the issues are discussed and precisely noted down. We then make the client aware of our terms of trade (which are also printed on the job sheet) and they then sign off on the job before any work is started.

The reverse applies when they pick the machine up; we demonstrate the machine running on the bench to confirm that all the listed problems have been resolved (and even run a virus scan to confirm that the machine is clean, if required). And again the client signs-off to confirm that the work has been done and that they've accepted this as final. This makes things easier should the machine later be returned with "the same" problem (eg, a virus re-infection).

Finally, if you are running a small business and are struggling with cash flow, seek a mentor. You won't regret it.

Now for some reader contributions. The first is from E. M. of Craigie, WA and concerns a puzzling fault in a ground-based aircraft-navigation aid. Here it is . . .

## Doppler VOR fault

This story concerns an unusual fault relating to a Doppler VOR at Perth Airport. A VOR is a ground-based navigation aid for aircraft. It transmits an encoded signal which is ultimately displayed in the aircraft as a bearing in degrees. The letters VOR stand for VHF Omnirange or VHF Omnidirectional Radiorange. And DVOR stands for Doppler VOR to distinguish it from earlier VORs which are referred to as "conventional VOR" or CVOR.

A VOR operates by radiating two different, timed 30Hz signals modulated onto RF carriers. One 30Hz signal is the reference and the second, which varies with azimuth or bearing, allows the time difference between the two to be measured by the aircraft's receiver and displayed in the cockpit as the bearing in degrees.

In operation, the Doppler VOR switches an RF signal around a large circle of antennas several metres in diameter, relying on the resultant Doppler shift at the aircraft to generate one of the 30Hz signals. A central aerial radiates the other 30Hz signal omnidirectionally. In addition, the VOR transmits an amplitude-modulated (AM) station identification in Morse Code.

Major airport DVORs also transmit pre-recorded voice weather information which is amplitude modulated on the same carrier as the station identification code. Of course, Doppler VOR operation is more complicated than this but this brief outline will suffice for our purposes.

In this particular case, pilots had been reporting that the DVOR's weather information was garbled. However, the beacon wasn't being turned off by the automatic monitoring system as it would if any major parameter such as course bearing or output power was out of tolerance.

The problem for us as maintenance technicians was that when the DVOR was tested with our specialist test equipment, it was found time and again to meet the required internationally prescribed performance standards. So what was it that pilots were reporting that we couldn't hear on a monitoring receiver, much less measure with instruments? Clearly, the pilots were reporting a real problem, so it was our job to find whatever it was, despite an apparently perfectly performing beacon.

Our initial thought was that, since the earliest reports came in during wet weather, we might be dealing with an intermittent connection due to moisture. It could even be something as obscure as some sort of change in earth resistance. The problem was that this just didn't seem to be the likely cause of an audio distortion fault. Wet weather was more likely to cause coverage problems or perhaps shift the course, which would have caused the beacon to shut down immediately, not create a "garbled audio" problem.

The voice information came to the DVOR hut via a few kilometres of underground cable from a recording device housed in another building. The only possibility left (but initially dismissed) was that a small amount of hum on the recorded weather information was causing the problem even though the VOR was performing to specification. In fact, there was no problem with the Morse code which should also have been garbled if it was a modulation problem. So perhaps the cable was occasionally going faulty in wet weather, increasing the perceived distortion.

As it turned out, the cable wasn't faulty, so that seemingly left only a faulty audio card. However, subsequent testing with an audio generator eliminated the audio card as the cause of any possible distortion. As part of the whole beacon, it too was performing to specification.

The problem – and the solution – turned out to be very obscure. At airports, there are many types of underground cables comprising standard telecommunications cables, very high-voltage runway lighting cables and other high-voltage and low-voltage mains cables. The only possibility left was that maybe in wet weather there was more hum induced into the control cable feeding the VOR but not enough to take it outside the limits of its specified operation and cause it to shut down.

The beacon's audio input amplifier was a conventional differential op amp circuit designed for a 600-ohm standard telephone line which received essentially a line-level input at about 0dBm, or about 0.8V RMS for those who prefer to work in volts. In theory, this differential amplifier should reject any common-mode hum unless, perhaps, it was beyond the common-mode rejection capability of the op amp.

As a first step, I decided to check if any 50Hz hum was present at the output of this first amplifier, without any pre-recorded audio present. However, the scope revealed something that looked more like a distorted 150Hz wave than anything else. It turned out that what I was seeing was 50Hz with a large third harmonic component present.

As I later learned, with magnetic induction, the presence of third harmonic components is quite usual. The amplifier module had rejection filters to eliminate anything below 300Hz and I wondered whether the amplifier wasn't able to reject enough of the offending 50/150Hz hum or if there was some kind of distortion from overload in the first stage to cause the weather forecast to sound slightly "garbled". I was a little stunned to find about 4V of this hum signal compared to about 1V of weather information.

So it looked like enough of this hum was getting through the first stage and the high-pass rejection filters to cause the reported garbling. It was all rather mysterious.

Next, I decided to measure the mains-induced hum level on each leg of the audio pair to ground, not really knowing what to expect. And it was here that the "fault" became really apparent. There was nearly 40V AC of this 50/150Hz hum to ground on each leg of the audio pair!

It now appeared as though the op amp's common-mode rejection was being overwhelmed. A single differential op amp stage wired in the configuration used has a maximum common-mode rejection ratio of about 16dB but the common-mode voltage in this case was much too high. And in any case, any signal above 10V RMS would overload the op amp inputs and


## Servicing Stories Wanted

**Do you have any good servicing stories that you would like to share in The Serviceman column in SILICON CHIP? If so, why not send those stories in to us? In doesn't matter what the story is about as long as it's in some way related to the electronics or electrical industries, to computers or even to car electronics.**

**We pay for all contributions published but please note that your material must be original. Send your contribution by email to:**

editor@siliconchip.com.au

**Please be sure to include your full name and address details.**

# A mouse in the house . . . & in the computer

D. S. of Maryborough, Qld, recently did battle with an old PC but the client was horrified at what he found. Here's his story . . .

A new client arrived one day carrying her desktop PC. According to her, it was dead but as it turned out, that wasn't quite the full story.

She left it with me and I began by setting it up and connecting a monitor, mouse and keyboard. As I quickly discovered, it wasn't entirely dead at all. Instead, it was "looping" during its boot-up routine. It would start up, give one long beep then shut itself down, wait two seconds and restart again, whereupon it would beep again and shut down. And on and on repeatedly.

This PC had definitely seen better days – well at least the case had, as it was missing a case fan and its shield. The I/O shield was also missing and the fan mounted on one of the side panels was so badly clogged with dust and fluff that it could no longer turn! Why did I ever get involved in servicing PCs?

The motherboard was a Gigabyte GA-EP43-US3L which was quite a good board for its time. In fact, I once ran one of these boards for over four years with no issues.

My first step was to get onto the internet to check the BIOS beep codes for this board. Many beep codes are universal and one long beep usually denotes a video issue, as in this case. This particular motherboard does not have on-board video, so I went straight for the graphics card.

The graphics card was an Nvidia GT9500 which has a PCIe interface. Thinking that the contacts might be dirty, I removed the holding screw, pulled the card from the slot and re-seated it, without even removing the video lead to the monitor.

On reboot, I was greeted with one long beep and two short beeps. That code essentially means the same thing – video problems! As a result, I removed the video card completely for a closer inspection and that's when I spotted the problem. The solder side of the card was covered in mouse droppings and traces of urine. This in turn had caused distinct discolouration of the tracks and the gold-plated edge connector. Mouse droppings are corrosive and this had not done the video card any good at all.

It was worthwhile attempting to resurrect the card so I cleaned the solder side with methylated spirits and the edge connector with contact cleaner. I then turned my attention to the PCIE slot on the system board which also showed signs of corrosion. This was scrubbed using an old toothbrush and contact cleaner and that removed all of the corrosion I could see.

By the way, never use abrasive paper to clean gold-plated contacts. The gold plating is usually not very thick and using abrasive paper will rapidly remove this plating. This can leave the copper pads exposed and when this comes into contact with the gold pins in the PCIe slot, you can get electrolysis.

While I was at it, I removed the RAM sticks, the CPU and the digital TV card and gave these a thorough clean. Removing all the dust and fluff from the CPU's heatsink and the fan would allow them to operate more efficiently. I also removed and cleaned the intake air filters on the case.

That done, I rummaged through my spares bin and found a fan and cover mesh to replace the missing units. At the very least, this would keep the mice out of the case and prevent further problems. I also found an I/O shield and although it wasn't a perfect match, a few small modifications had it fitting where it mattered.

Finally, I reassembled the PC and hit the power switch. This time, there was a single (correct) beep from the BIOS, followed by the usual BIOS and video BIOS messages on the monitor. The machine then booted normally into Windows XP and a full check of the various items in hardware manager showed no issues.

I left the PC running for a day, with several benchmarking programs giving a decent result. I then duly rang the owner to give her the good news. She was overjoyed to hear that her PC was now working because she didn't want to buy a new one. However, my news about the rodent damage was not so gleefully received.

"My home does not have mice", was her indignant reply so I asked her to have a look around the desk where her PC sits. Sure enough, she found droppings and bits of shredded paper behind her desk.

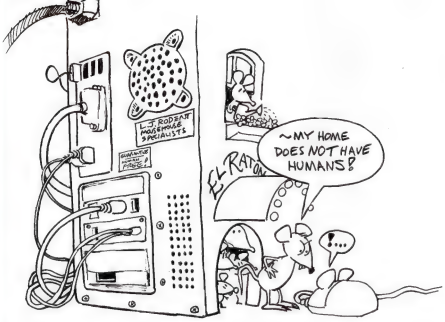
This was a quick job and I really didn't have the heart to charge her for my time – her shock when she realised that there were mice in her home was quite enough. The mouse connected to her PC was the only one she really wanted to see!

then it could not reject the common mode signal at all.

It then occurred to me that we could use a balanced transformer to reject the common-mode hum and give the op amp a helping hand, as was often done in console audio systems, mixers and telephone systems.

Fortunately, the audio input came into the VOR shelter via a cable connected to Krone terminating blocks. This made it easy to temporarily install a transformer to see if it made any difference. The result was dramatic – the combined 50/150Hz hum at the output of the first audio amplifier stage was reduced from about 4V to less than the pre-recorded audio.

So maybe this would solve the problem and clean up the transmitted weather information. But what was still puzzling was that the automatic monitoring system had always determined that the DVOR was working at the required international standards. What's more, this "fault" was only being intermittently reported and then by only one or two pilots out of the hundreds that used it and at first only in wet weather.




Initially not believing what I was seeing, I removed the transformer and the hum at the output of the first stage returned to 4V – a pretty conclusive result. So a transformer was required and because the incoming audio line was from an underground cable, we used an approved high-voltage audio transformer that met the general telecommunications requirements for safety (this was in addition to the standard lightning arrestor unit attached to the cable).

Once the transformer had been permanently fitted, there were no further reports of "garbled" weather information. And coincidentally, this technique also gave us the solution to some audio system hum at the control tower, which we had been mulling over at the same time. Once again, adding a simple balancing transformer eliminated the hum. It shows the need for accurately balanced audio circuits over lines of almost any length, from a few metres to kilometres.

## Intermittent TV repair

Most CRT TV sets have now gone to landfill and most people would say good riddance. They certainly provided more than their fair share of problems and some years ago, A. P. of Briar Hill, Victoria took on one with a nasty intermittent fault. Here's his story . . .

Intermittent faults can be extremely difficult to track down. For one thing, the symptoms may disappear before a diagnosis can be made and it may then take hours, days or even longer for them to reappear. It can also be difficult to know whether or not an intermittent fault has been truly fixed.

This story relates to the days before plasma and LCD TVs. The footy finals were fast approaching and my friend liked nothing more on a Saturday afternoon than to sit in front of the TV and watch the big match. However, much to his frustration and usually at critical moments in the game, the picture would suddenly become very bright and washed out, at the same time being overlaid with thin diagonal white lines spaced evenly across the screen.

He had discovered that getting up and giving the cabinet a sharp whack would temporarily fix the problem but his worry was that the occurrences were getting more frequent. In fact, it was getting so bad that he was sure that his enjoyment of the finals would be ruined. And so, knowing that I had an interest in electronic repairs, he asked if I could have a "look at it".

From his description, it sounded like there was an intermittent fault in the retrace line suppression circuit which cuts off the CRT electron beam between the times it is needed to deliver the picture. Anyway, I told him that I thought I could fix it provided the fault showed itself and so I called in the following Sunday to find the TV on its very best behaviour. I took off the back and poked and prodded but could not make the fault appear.

At that stage, there was nothing I could do except put it back together, pack up my tools and go home. Of course, later that day during the football match, the fault recurred much to my friend's frustration.

The following weekend I made another visit. By this time, at my urging, my mate had obtained a circuit diagram and this allowed me to narrow down the likely fault area on the circuit board. But once again, no amount of coaxing would make the fault appear.

By now, my friend was becoming somewhat impatient. He had seen my workshop and couldn't understand why I had been poking around inside his TV with just a length of plastic rod when I had all that great test gear.

I tried to explain that while ever the fault was absent, no amount of test gear could track it down. However, I couldn't help feeling that he was thinking that maybe it would better to have the TV looked at by someone more competent than yours truly. And so I returned home once more, feeling that my credibility was in tatters.

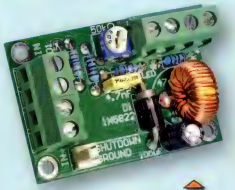
A couple of days later, I learned that the TV had played up an hour or so after I'd left. I told him that I would look at it again for him at the first opportunity. By now, my curiosity as to what the fault might be had been thoroughly aroused and I felt cheated that I had been unable to nail it because it wouldn't appear while I was present.

The very next weekend, my friend phoned to say that it was playing up again. I told him to touch nothing and that I would be there shortly. Sure enough, when I arrived, the fault was present, complete with retrace lines for me to see for the first time.

I gently removed the back with the set running. I now knew the area of the circuit board to examine and after a few minutes of very gentle but judicious prodding with a plastic knitting needle, the fault suddenly disappeared and could not be made to reappear. Still, I knew the area where the prodding had been effective.

With the set turned off, I withdrew the PCB as far as the leads would allow. It was then necessary to fold aside a rectangular piece of red fibre board in order to examine the copper tracks and solder joints in the suspect area. And sure enough, there it was – a dry joint at the end of an insulated jumper wire.

Re-soldering this joint fixed the fault for good. And although it took a lot of time, few repairs have been as satisfying. In the process, I had saved my friend a lot of time and money. If he had ferried the TV back and forward to a repairer, he would have had to pay for the work. And who knows how many trips it might have taken to get the fault finally nailed. SC




The MiniSwitcher gives a regulated output from 1.2-20V at currents up to 1.5A and doesn't require a heatsink.

# Simple 1.5A Switching Regulator

By NICHOLAS VINEN

**This tiny regulator board outputs 1.2-20V from a higher voltage DC supply at currents up to 1.5A. It's small, efficient and cheap to build, with many handy features such as a very low drop-out voltage, little heat generation and electronic shut-down.**

IN THE DECEMBER 2011 issue, we presented the MiniReg, an update to our LM317-based 1.3-22V adjustable linear regulator. This has been a very popular kit over the years because it's cheap, simple and can be adjusted to suit whatever voltage you need.

But while an LM317 regulator circuit might appeal to old dudes and codgers, it's so "1980s"! For anyone in their thirties or younger, it's just plain boring. In fact, the LM317 was designed in 1970 by two engineers working for National Semiconductor. That's over 40 years ago, well before I was born! And while linear regulators are still in use in many applications (yeah, yeah, still boring), these days, just about every computer, monitor and TV (and a lot of other gear) uses switchmode regulation.

The benefit of switchmode regulators is much higher efficiency. This means lower power consumption, less heat and cheaper components (eg, smaller transformers and heatsinks etc). Small size, light weight and low power consumption are particularly important for portable electronic gear.

In short, for a large range of applications, why would you bother with linear regulation? Linear regulators only have to be used if you need very low noise and ripple and for EMI-sensitive applications like radios. For just about everything else, switchmode is the way to go.

Just look at the photo towards the end of this article – it shows how large a heatsink you need to get the rated current of 1.5A from the MiniReg with a 14.4V input and a 5V output (ie, when the power source is a lead-acid battery). That is no longer a small or cheap regulator!

Then there's the fact that a lot of linear regulators have quite a large "dropout voltage". This is the minimum difference between input and output voltage. For example, to get a regulated 12V, you generally need at least a 15V input (unless you are using a low-dropout regulator or LDO).

If you are using the MiniReg as a speed controller for the Magnetic Stirrer project in the December 2011 issue, you can't run the fan at full speed if you are using a 12V power supply. In that application, it isn't a problem but sometimes the high drop-out voltage is a serious inconvenience (and it increases the dissipation as well, because the supply voltage is higher than it would otherwise need to be).

## Main Features

- Wide operating voltage range
- Very low drop-out voltage
- High efficiency
- No heatsinking necessary
- Electronic shutdown
- Thermal, overload and short circuit protection
- Soft start
- Provision for power switch & LED

## Enter the MiniSwitcher

With only a modest increase in size and complexity, this design overcomes all those limitations. Like the elderly LM317, the chip we use here (the AP5002) has an adjustable output voltage, can deliver around 1.5A and it also has over-temperature and over-current protection. But unlike the LM317, it has a very low dropout voltage (about 0.1V) and doesn't need a heatsink, even with maximum input voltage and at the full load current of 1.5A.

Because it dissipates a lot less heat, that also means that less of the input supply power is wasted. Plus it has an electronic shut-down feature, allowing

a micro or other logic circuit to turn it off if necessary. In this "sleep" mode, it draws very little current.

The only real disadvantage of a switchmode regulator (besides the extra complexity) is the high-frequency ripple on the output due to the switching action. But since the AP5002 operates at such a high frequency (typically 500kHz), the ripple has a low amplitude and sub-harmonics are not audible. It can be reduced even further by an external LC filter, to suit a particular application.

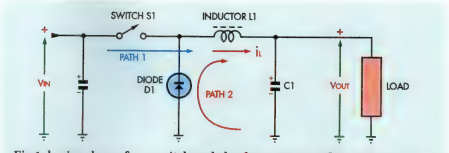



**Fig.1: basic scheme for a switchmode buck converter. Voltage regulation is achieved by rapidly switching S1 and varying its duty cycle. The current flows via path 1 when S1 is closed and path 2 when it is open. In a practical circuit, S1 is replaced by a switching transistor or a Mosfet.**

## Regulation

So why do you need a regulator anyway? Well, there are a number of reasons.

If you have a device which must run at a particular voltage (eg, 5V ± 0.5V or 4.5-5.5V), then you could just use a regulated plugpack or bench supply. However, depending on the length and thickness of the supply leads and the unit's current consumption, there will be a voltage drop before the power reaches the device.

Even if the supply is putting out exactly 5V, it's possible that it may be below the minimum (in this case, 4.5V) by the time it reaches the unit. What's worse, as the unit's current draw changes, so will the voltage it receives, due to the cable drop and the output impedance of the power supply itself.

Local regulation solves this problem. By placing a regulator board in close proximity to the device being powered and feeding a higher voltage to it, changes in the power supply's output voltage become irrelevant.

Also, there are times when (for various reasons) you want to use a linear power supply, eg, a mains transformer with its output rectified and filtered. Not only can the output voltage of this type of supply vary quite a bit with load but there is also 50/100Hz voltage ripple, due to the fact that the filter capacitor(s) charge and discharge over each mains cycle. This can cause hum in audio equipment and various other problems.

An efficient switchmode regulator can turn this rather variable output into a nice, stable supply with a minimum of energy being wasted as heat.

## Switchmode basics

Before going further, let's take a look at how a step-down (or "buck") switchmode regulator works. Fig.1 shows the basic circuit. It uses a switch (in practice, a switching transistor or a Mosfet) to rapidly connect and disconnect the incoming power supply to the input end of inductor L1. The other end of the inductor connects to filter capacitor C1 (which acts as an energy storage device) and the load.

As shown by the blue line labelled "PATH 1", when the switch is closed, current flows through the inductor and then the load. The rate of current flow ramps up linearly as the inductor's magnetic field strength builds.

Then, when the switch opens, the current flow from the input supply is interrupted and the inductor's magnetic field begins to collapse. This continues driving current into the output but at a diminishing rate. While the switch is open, the output current is sourced from ground, via diode D1 (the red line shown as "PATH 2").

In practice, because this current then flows to ground after passing through the load, it actually travels in a loop, through D1, L1, the load and then around again until either the inductor's magnetic field is fully discharged or switch S1 closes again.

By varying the switch on/off ratio, the average current through the inductor can be controlled and this, in combination with the load characteristics, determines the output voltage. The ratio of the switch on-time to the switching period (on-time plus off-time) is known as the duty cycle. However, because the inductor and load properties can vary, for a constant output voltage we can't use a fixed duty cycle.

Instead, the output voltage is monitored and if it is too low, the duty cycle is increased. Conversely, if the output voltage is too high, the duty cycle is decreased. This negative feedback provides the required regulation.

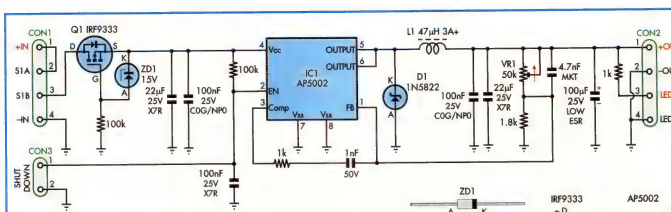
There's a bit more to it than that but in practical circuits, most of the details are taken care of by a switchmode IC.

## Circuit description

We decided to use an AP5002 after surveying the range of switchmode

### Specifications

| | |
|---|---|
| Input voltage | 3.6 to 20V (absolute maximum 22V) |
| Output voltage | 1.2-20V (must be below input voltage) |
| Dropout voltage | typically 0.1V at 1A |
| Output current | at least 1.5A |
| Efficiency | can exceed 90%, typically over 85% |
| Switching frequency | approximately 500kHz |
| Quiescent current | 3mA (10µA when shut down) |
| Load regulation | ~1%, 1.5A step |
| Line regulation | ~2%, 4-20V |
| Output ripple | <5mV RMS at 1.5A (see Fig.2) |
| Transient response | ~250mV overshoot, ~100mV undershoot, 1A step |




## SC 2007 MINISWITCHER 1.2-20V REGULATOR

**Fig.2: the complete switching regulator circuit. Mosfet Q1 provides input reverse polarity protection while IC1 does the switching and regulation via negative feedback. Inductor L1 filters the output in combination with three capacitors across the ouput rail, while trimpot VR1 provides output voltage adjustment.**

regulator ICs available. This device has a good range of features and is low in cost.

Fig.2 shows the circuit details. It's based on the data sheet but with several important changes.

As well as the switchmode regulator (IC1), you should recognise inductor L1 and Schottky diode D1 from the explanatory diagram (Fig.1). While the recommended inductor value is 10-22µH, we found that 47µH provides better duty cycle stability over a range of input and output voltages and load currents. It's also a more common value and it provides better ripple filtering than a lower value inductor.

Both the input and output lines are filtered using low-value (100nF) and high value (22µF) ceramic capacitors in parallel. This results in a very low ESR (equivalent series resistance) across a wide range of frequencies, reducing the current spikes in the input and output wiring. Note that the 100nF capacitors are specified with a ceramic C0G dielectric, as this provides the best performance over the widest range of frequencies and temperatures.

Trimpot VR1 allows the output voltage to be adjusted. It forms part of a resistive voltage divider which is in the feedback path from the output to IC1's FB (feedback) input at pin 1. IC1's negative feedback keeps its FB pin at around 0.8V. This means that in order to get a 5V output (for example), VR1 is set to around 9.45kΩ. In practice, you just turn VR1 until the desired output voltage is achieved.

VR1 is in the upper half of the feedback divider, with a 1.8kΩ resistor in the lower half, as this provides a more linear and progressive adjustment. However, there are advantages to using the opposite configuration (ie, with VR1 between FB and ground), the primary one being that if VR1 goes open circuit, the output voltage goes down rather than up. But then it's trickier to set the desired voltage.

The 4.7nF capacitor across VR1 is a "feed-forward" capacitor which reduces the gain of the feedback system to unity at high frequencies. This improves the circuit's stability, like the capacitor across the feedback resistor often seen in op amp circuits.

The 1nF capacitor and 1kΩ resistor in series between pins 1 (FB) and 3 (Comp) of IC1 also work to improve the loop stability of the regulator. These components provide frequency compensation, hence the labelling of pin 3. Pin 1 connects to the input of IC1's internal error amplifier while pin 3 connects to the output and so these components are in the feedback loop and limit the slew rate of the error amplifier output.

Pin 2 of IC1, labelled "EN", is the enable input. If this is pulled low, the regulator shuts down – its internal switch turns off, the output pins go high impedance and its quiescent current drops to 10µA. A 100kΩ pull-up resistor to Vcc enables the regulator by default, while a 100nF capacitor filters the voltage at this pin to prevent the EN pin from rapidly toggling due to EMI (electromagnetic interference).

EN can be driven low for shut-down and simply pulled high (via a resistor) for normal operation. Alternatively, it can be actively driven high and low. However, if actively driven high (not used here), the high voltage must be below Vcc. It's also a good idea to drive the EN pin via a series resistor of about 2.2kΩ, to protect IC1.

The input supply is normally connected to terminals 1 (positive) and 4 (negative) of CON1. A power switch can then be connected between terminals 2 and 3. If you don't want a power switch, you can simply connect a short piece of wire (eg, 1mm tinned copper wire) between terminals 2 and 3. Alternatively, the positive input supply can be connected directly to terminal 3.

P-channel Mosfet Q1 (a surface-mount type) protects IC1 against accidental reversal of the supply voltage polarity. This is a logic-level device with a very low on-resistance, so it can operate down to the minimum supply voltage for IC1 (3.6V), In addition, during normal operation, very little power is lost in Q1. Its on-threshold is typically 1.8V (maximum 2.4V), so by 3.6V its channel resistance is already quite low – around 33mΩ at 4.5V and 20mΩ at 10V and above.

If the input supply voltage has the correct polarity, Q1's gate is pulled below its source, which is initially no more than one diode drop below its drain. This is connected to the positive supply lead (clamped by the parasitic body diode). Since Q1 is a P-channel type, this turns it on. Its maximum

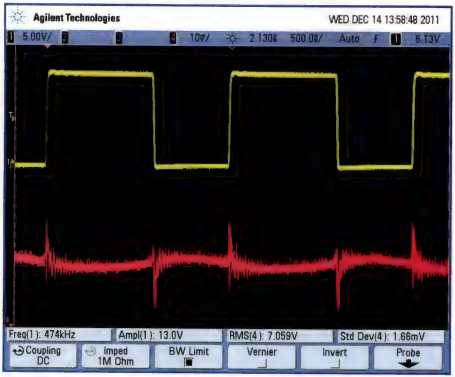



**Fig.3: this shows the operation of the unit with 13V in and 7V out at 1.5A. The yellow trace is the voltage at the output pins of IC1 while the mauve trace shows the voltage across the load. The spikes in the latter trace corresponding with the output transitions are due to inductance in the scope probe ground lead. If you ignore that, there's only a few millivolts of ripple at the regulator output.**

gate-source voltage rating is 20V, so zener diode ZD1 limits this to around 15V (for higher supply voltages).

However, if the supply voltage is reversed, Q1's gate is instead pulled above its source and so Q1 is off. The parasitic body diode is now reverse-biased, so no current can flow into the circuit. ZD1 clamps the gate to no more than one diode drop above the source, with some current flowing through the 100kΩ resistor (up to a maximum of 0.22mA at 22V).

With a correctly polarised supply voltage above 15V, ZD1 conducts and a small amount of the supply current passes through Q1's 100kΩ gate resistor. This is no more than about 70µA at the maximum allowable supply voltage (22V). Below 15V, Q1's gate has a very high resistance and so once its gate capacitance has charged up and Q1 is on, only a tiny current flows.

The output voltage is available from terminals 1 & 2 of CON2. A LED can be connected between terminals 3 and 4, to indicate when the regulator is operating. The specified 1kΩ current-limiting resistor will suit some combinations of output voltage with some standard LEDs but may need to be reduced for other combinations (ie, lower output voltages and/or blue or white LEDs).

## Transient response

The 100µF electrolytic capacitor in parallel with the output filter has been added to improve transient response. If the regulator's load suddenly drops (ie, its impedance increases), the output isn't immediately reduced to compensate. This is partly due to energy stored in the inductor and partly due to the frequency compensation scheme required for stable operation.

The result is a temporary spike in the output voltage. By increasing the output capacitance, we reduce the amplitude of this spike.

With the circuit as shown, we measured an overshoot of around 0.25V with a step of over 1A. The undershoot when the load impedance suddenly drops (ie, current demand increases) is much lower, at less than 0.1V. These figures should be acceptable in most applications and will be reduced further by any input capacitance associated with the load – typically several hundred microfarads.

Note that we have specified a low-ESR type for the 100µF filter capacitor so that it has sufficient ripple current capability. These are also usually rated for 105°C operation. Capacitors this small are usually only rated for around 500mA ripple current but in this regulator, the ripple is quite low and so heating isn't a problem. In operation, the electrolytic capacitor is normally only heated to about 10°C above ambient (tested at 1.5A).

## Parts List

1 PCB, code 18102121, 49.5 x 34mm (available from SILICON CHIP)
1 47µH 3A inductor (L1) (Altronics L6517)
1 50kΩ mini horizontal trimpot
4 2-way terminal blocks, 5mm or 5.08mm pitch (CON1, CON2)
1 2-way polarised header (CON3)
3 M3 x 6mm machine screws
3 M3 x 12mm tapped spacers

**Semiconductors**
1 AP5002SG-13 switchmode regulator [SOIC-8] (IC1) (Element14 1825351)
1 IRF9333 P-channel Mosfet [SOIC-8] (Q1) (Element14 1831077)
1 1N5822 3A Schottky diode (D1)
1 15V 400mW/1W zener diode (ZD1)

**Capacitors**
1 100µF 25V low-ESR electrolytic
2 22µF 25V X7R ceramic [4832/1812] (Element14 1843167)
3 100nF 25V NP0/C0G ceramic [3216/1206] (Element14 8820210)
1 4.7nF MKT
1 1nF 50V NP0/C0G ceramic [3216/1206] (Element14 1414710)

**Resistors (0.25W, 1%)**
2 100kΩ
1 1.8kΩ
2 1kΩ

## Construction

The MiniSwitcher is built on a PCB coded 18102121 and measuring 49.5 x 34mm. This has been designed as a double-sided PCB with some plated-through holes and the top layer acting as a ground plane to reduce electromagnetic interference (EMI).

Fig.4 shows where the various parts go. Begin the assembly by installing IC1 on the underside of the PCB. This

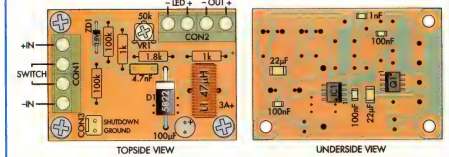
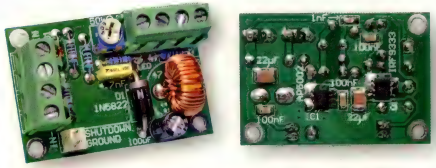



**Fig.4: the regulator is built on a small double-sided board and utilises both surface-mount and through-hole components. The top layer is a ground plane, minimising the current loops and thus keeping electromagnetic radiation outside the board to a low level.**




**These top and bottom same-size views show the fully-assembled PCB. You will need a soldering iron with a fine conical tip to solder in the surface-mount parts. Unwanted solder bridges can be removed using solder wick.**

is in a surface-mount 8-pin SOIC package and its pins are sufficiently spaced for it to be soldered with a regular iron.

First, check that it is orientated correctly, with its pin 1 towards the bottom edge of the board. That done, line its pins up with the pads and solder them in place. If your IC doesn't have a dot to indicate pin 1, check to see whether it has a bevelled edge, as shown on Fig.4.

Because its output and ground pins connect directly to its internal Mosfet switch, these are soldered to two large pads for better heat dissipation. The other four pins connect to individual pads as usual. Use fresh solder and ensure it has been heated enough to flow properly.

If you don't do this, it's possible for solder to adhere to one of the pins but not actually flow under the pin and onto the associated pad.

Install Mosfet Q1 next, using the same technique. It too has large pads for its multiple drain and source pins. Be careful because **its orientation is opposite to IC1, ie, its pin 1 goes towards the top of the board.**

Now check IC1 and Q1 for any unwanted solder bridges between adjacent pins (ie, ignore those between pins that solder to the same pad). If you do find any, they can be easily removed using solder wick (or desoldering braid).

The 100nF and 1nF ceramic capacitors in the 3216/1206 packages are next on the list. The easiest way to install these is to first melt some solder onto one of the pads. You then hold the capacitor alongside this pad using tweezers, reheat the solder and slide the capacitor into place.

If you don't get it perfectly positioned on the first attempt, just reheat the solder and adjust it slightly. That done, solder the other pad, then go back to the first one and apply a little fresh solder, to reflow it and form a proper joint. The two larger 22μF ceramic capacitors can then be installed using the same procedure.

## Through-hole parts

You can now proceed to install the through-hole parts, starting with the resistors. Check the values with a DMM before installing them, then fit diode D1 and zener diode ZD1, taking care to orientate them correctly.

Follow with trimpot VR1, the 4.7nF MKT capacitor and then the terminal blocks. Be sure to dovetail the 2-way terminal blocks together (to make 4-way blocks) before pushing them down fully onto the PCB and soldering their pins. Make sure that their wire entry holes face towards the adjacent edge of the PCB.

Note that there is provision on the board for the load and/or LED to be connected via a polarised header instead of a terminal block. This could be useful for loads drawing under 1A, such as computer fans. If you decide to install polarised headers instead, check the polarity of the fan plug and orientate them accordingly. You can mix and match 2-way terminal blocks and polarised headers if you like.

The polarised header for the shutdown feature can then be fitted at bottom left. Orientate it as shown on the overlay diagram (Fig.4). The 100μF electrolytic capacitor can then be installed, followed by inductor L1 (47μH).

The assembly can now be completed by fitting three M3 x 12mm tapped spacers to the corner mounting holes.

## Setting up & testing

The first step is to turn VR1 fully anti-clockwise, then back it off a little. That done, connect a power supply between terminals 3 & 4 of CON1 (eg, a 12V plugpack or a bench supply). The

### Table 1: Resistor Colour Codes

| No. | Value | 4-Band Code (1%) | 5-Band Code (1%) |
|---|---|---|---|
| 2 | 100kΩ | brown black yellow brown | brown black black orange brown |
| 1 | 1.8kΩ | brown grey red brown | brown grey black brown brown |
| 2 | 1kΩ | brown black red brown | brown black black brown brown |

**This photo of the MiniReg linear regulator (December 2011) shows just how inefficient it is compared to the MiniSwitcher. This is the size of heatsink it requires in order to handle a current of 1A if there is a large voltage differential between input and output (eg, 14.4V input and 5V output). By contrast, the MiniSwitcher can handle currents up to 1.5A and doesn't require a heatsink at all, regardless of the input-to-output difference.**

positive lead should go to terminal 3. It's also a good idea to connect a DMM set to measure current in series with the supply, if possible.

You may also want to connect a LED across terminals 3 & 4 of CON2, with the anode (longer lead) to terminal 3. Depending on the output voltage and LED colour, it will be driven at 1-20mA. If the LED is too dim (eg, at low output voltages), use a lower value resistor and if it is too bright, increase the value. For output voltages of 5V and below, it's probably a good idea to change this resistor to 300-470Ω, while for output voltages above 12V, you may want to increase it to, say, 2.2kΩ.

Note, however, that the LED will not light if the regulator's output voltage is lower than the LED's forward voltage (1.8V for a red LED and 3.3V for a blue LED).

If you want to use a 12V LED (ie, one with a built-in resistor) and the output voltage is no more than say 15V, replace the 1kΩ resistor with a wire link. Alternatively, the LED can simply be connected across the output terminals, in parallel with the load.

Now apply power and check that the current quickly drops to just a few milliamps. Assuming it does, check the voltage at the output, ie, between pins 1 & 2 of CON2. This should be around 1V, depending on the exact position of VR1. If this is correct, turn VR1 and check that this adjusts the output voltage.

Note that you may hear some whine from the inductor if you set it below 1.2V, as this typically results in some sub-harmonic oscillation.

Assuming all is well, adjust VR1 to give the desired output voltage. It's a good idea to make the final adjustment later, with the power supply you will be using in your application (assuming it's different from the one you're using for the set-up).

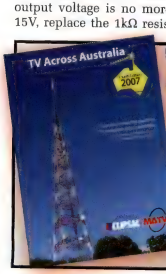
If you have a low-value, high-power resistor (eg, 4-10Ω 10W), connect it across the output terminals and check that the set voltage is maintained. This assumes that with your set voltage, the current draw will be within the permissible range (up to 1.5A) and that your test supply can deliver enough power to the regulator.

## Troubleshooting

If the board isn't working, switch off and check the solder joints with a magnifying glass. In particular, check IC1 and Q1 carefully, as it isn't always obvious when the solder has adhered to a pin and not to the pad.

Assuming there are no soldering problems, the other likely cause of a fault is an incorrectly orientated component or a part installed in the wrong location or having the wrong value.

If all is well, install the regulator board into the chassis you want to use it in and monitor the output voltage while making the final adjustment to VR1. You can then use a dab of silicone sealant or hot-melt glue to prevent it from being changed accidentally. SC


*We thought we'd run out. . . but there on the back of the shelf . . .*

**LAST FEW: SAVE $$$**

**TV ACROSS AUSTRALIA**

**Your easy reference guide to TV reception across Australia**

Travelling around Oz? Want to know where to aim your antenna? This book will tell you! Lists channels, location and polarity of all analog transmitters and translators (digital services are usually co-sited). A MUST-HAVE with loads of other TV-related data too! Even if you aren't travelling, this is highly useful in troubleshooting local TV reception problems. All this information in one handy source!

Buy direct from Silicon Chip bookshop

RRP: ~~$39.95~~

ONLY while stocks last:

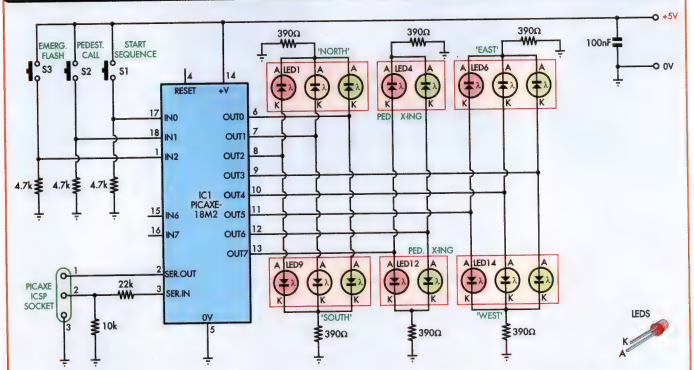
**$29.95** +p&p

*STRICTLY FIRST COME, FIRST SERVED. VERY LIMITED STOCKS LEFT!*

SEE P98 for handy order form

# CIRCUIT NOTEBOOK

**Interesting circuit ideas which we have checked but not built and tested. Contributions will be paid for at standard rates. All submissions should include full name, address & phone number.**




## PICAXE-based traffic light sequencer

This circuit uses a PICAXE-18M2 microcontroller to sequence model traffic lights at a 4-way intersection. The east-west direction also includes a pedestrian crossing signal which is triggered with a pushbutton and then occurs at the appropriate point in the sequence.

The usual red-green-amber-red sequence is implemented with appropriate delays. With the circuit as shown, the sequence does not start until pushbutton S1 is pressed but it can be omitted and replaced with a link so the sequence automatically starts at power up. Pushbutton S2 is used to trigger the pedestrian crossing signal, which turns green simultaneously with the north-south traffic lights. Pushbutton S3 causes the amber lights in all four directions to flash, which normally occurs when the traffic light control system fails. All three pushbuttons have associated pull-down resistors so the PICAXE can detect when they are pressed.

The lights are appropriately coloured LEDs. Since only one LED within a set is illuminated at a time, they are wired with a common cathode and a single 390Ω current-limiting resistor. This sets the LED current to about (5V - 2V) ÷ 390Ω = 7.7mA. The LEDs and resistors for the south and west directions are wired with their anodes in parallel with those for the north and east directions respectively but with separate current-limiting resistors.

An in-circuit programming header is provided and the software can be downloaded from the SILICON CHIP website (TrafficLights18M2.bas). The software can be modified to change the timing if desired.

**Phillip Webb,**
**Hope Valley, SA. ($60)**

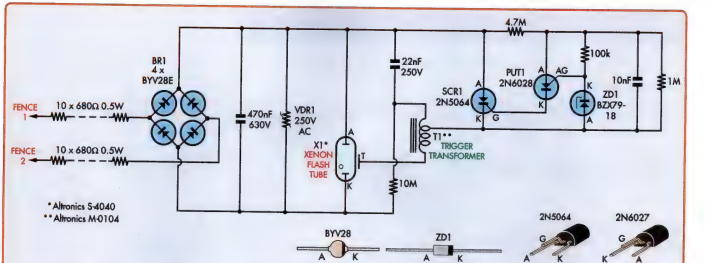
## Contribute And You Could Win An LCR Meter

We pay for each of the "Circuit Notebook" items published in SILICON CHIP but there is another reason to send in your circuit idea.

Each month, at the discretion of the editor, the best contribution published will entitle the author to a nifty, compact LCR40 LCR meter, with the compliments of Peak Electronic Design Ltd – see **www.peakelec.co.uk**

So send that brilliant circuit idea in to SILICON CHIP and you could be a winner.

You can either email your idea to silicon@siliconchip.com.au or post it to PO Box 139, Collaroy, NSW 2097.




## Electric fence tester uses Xenon flash tube

This circuit is an adaptation of the Maxi Electric Fence Tester published in SILICON CHIP, May 1999. Like that circuit, this one uses a Xenon flash tube to give a visible indication of a working electric fence. However, this particular circuit can handle higher-power Xenon tubes.

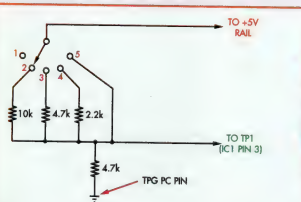
Power for the circuit is derived directly from the fence. And while each flash involves a hefty burst of energy, this energy is built up progressively through successive pulses from the fence so that the average power consumed by the circuit is relatively small. As a result, the circuit can be permanently connected to the fence without significantly diminishing the effectiveness of the latter.

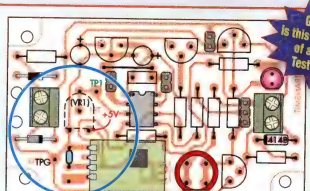
A feature of this circuit is that it operates independently of the polarity of the fence pulses, by virtue of its bridge rectifier. The three capacitors (470nF, 22nF & 10nF) are progressively charged via the diode bridge and a resistor ladder consisting of 20 680Ω 0.5W resistors (to provide an adequate voltage rating).

When the voltage across the 10nF capacitor is close to or exceeds the breakdown voltage of zener diode ZD1, programmable unijunction transistor PUT1 conducts and triggers SCR1, to dump the charge from the 22nF capacitor into the primary of trigger transformer T1. TI steps up the pulse voltage to fire the Xenon tube which then discharges the 470nF capacitor to produce a bright flash.

While the circuit should work with most types of Xenon tubes, such as found in typical camera flash units, it is preferable to use a tube specifically designed for strobe applications, to ensure a reasonably long operating life.

**Herman Nacinovich,**
**Gulgong, NSW. ($45)**




**Geoff Coppa is this month's winner of a Peak Atlas Test Instrument**

## Operating multiple 433MHz UHF remote switches

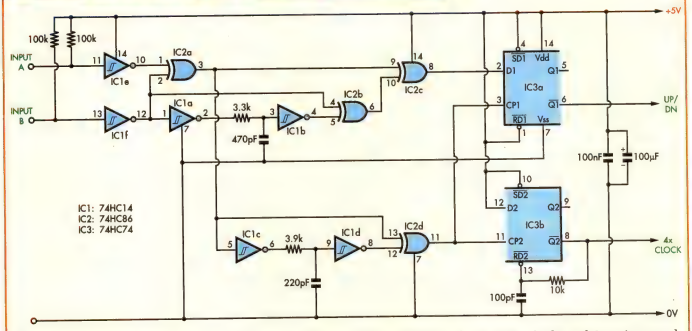
The 433MHz UHF Remote Switch (SILICON CHIP, January 2009) is handy for tasks such as switching water pumps on and off on a farm. In this type of situation, it's desirable to have a single transmitter control multiple receiver units. This circuit modification allows that.

Originally, one of five transmitter/receiver identities was selected by adjusting trimpot VR1 for a particular voltage on pin 3 (AN3) of microcontroller IC1. For multiple transmitter identities, the trimpot is replaced with a 5-position rotary switch (S1) and four resistors which form a switched voltage divider.

In position 1, the 4.7kΩ resistor pulls pin 3 of IC1 to ground (0V) which selects identity 1 (0-1V). In positions 2-4, the voltage is set to roughly 1.5V, 2.5V and 3.5V respectively by the voltage divider formed between the 5V and 0V rails. In position 5, pin 3 is pulled up to 5V, selecting identity 5 (4-5V).

Having set the rotary switch, the transmitter button can then be pressed to switch the remote load. The receivers are set to the appropriate identities as described in the original article.

**Geoff Coppa,**
**Toormina, NSW.**




## Quadrature decoder for motor feedback

Rotary encoders are used for motor speed/direction feedback and for control knobs. They normally produce two square waves, A and B, which are 90° out of phase. Each output gives one pulse per rotation (encoders designed for high-speed use) or multiple pulses per rotation (those designed for precision).

In many applications, it is necessary to convert these signals into two different signals, one indicating the direction of rotation and the other giving a fixed number of pulses per rotation, regardless of direction.

There are various circuits to do this but most of them either miss very short pulses or do not work well for low-speed rotation. There are ICs designed for this task this but they aren't commonly available and are relatively expensive.

This circuit is very reliable and is based on three common logic ICs. It produces four pulses on the speed output per revolution (ie, one for every edge transition from the rotary encoder outputs) while some other circuits only produce one. This allows much more accurate speed/position feedback.

IC1 is a 74HC14 hex Schmitt-trigger inverter, IC2 is a 74HC86 quad XOR (exclusive OR) logic gate and IC3 is a 74HC74 dual D-type flipflop. Inverter stages IC1e and IC1f clean up and invert the A & B pulses from the rotary encoder, while the 100kΩ pull-up resistors on the inputs are included since some rotary encoders require them.

Both signals are then fed into IC2a, one of the XOR gates. The output of an XOR gate is high whenever the inputs levels differ and low the rest of the time; you can think of it in a sense as a single-bit comparator. IC2a's output is a square wave with a transition whenever the state of either input changes. This is then inverted by IC1c and delayed by an RC low-pass filter consisting of a 3.9kΩ resistor and 220pF capacitor. The delayed signal is then cleaned up and re-inverted by IC1d.

XOR gate IC2d then compares the two series of pulses – those from IC2a and the delayed version – resulting in a positive pulse whenever they differ, ie, at each transition edge. The result is four pulses per rotation, each lasting around 850ns.

These pulses are then fed to the clock input (pin 11) of IC3b, a D-type flipflop which acts as a monostable oscillator to stretch and invert the pulses. Since its data pin 12 is tied to +5V, on a positive clock transition, its output at pin 9 goes high and the inverted output at pin 8 goes low. Pin 8 then discharges the 100pF capacitor through the 10kΩ resistor and after about 1µs, the reset input at pin 13 goes low, bringing the inverted output (Q2) high again.

The output from IC2d (ie, four pulses per revolution) is also fed to the clock input of IC3a which detects the direction of rotation. To do this, when its pin 3 clock input goes high, the input pin 2 data level must indicate the phase lead/lag of Input A relative to Input B. This requires a phase detector circuit which consists of IC1a, IC1b, IC2b & IC2c.

The output of IC1a follows Input B, having been inverted twice. It is then delayed by about 1.5µs by an RC low-pass filter (3.3kΩ & 470pF). The delayed signal is then cleaned up and inverted by IC1b and fed to IC2b, which compares the delayed signal to the original. The output at pin 6 produces one positive pulse for each edge transition of Input B.

These pulses are then XORed with the difference signal from IC2a. The result is a signal that, at the time when the output of IC2d goes high, has a level which indicates whether pulses from Input A lag or lead those from Input B. In practice, the output level of IC3a (at pin 6) only changes after the first pulse from the rotary encoder after its direction of rotation reverses.

**Les Kerr,**
**Ashby, NSW. ($50)**

## Eye-level display for bathroom scales

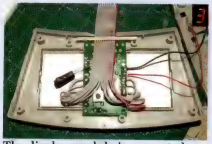
These days you can obtain attractive glass bathroom scales for around the $20 mark but the LCD readout can be difficult to read if you are short-sighted or have an excessive girth problem. In addition, such scales are virtually useless for weighing parcels or luggage due to the display being covered by the object being weighed.

All of these drawbacks could be solved if the bathroom scale had an eye-level display; no more peering at your feet! This can be done relatively easily and virtually no electronics knowledge is required.

The first step is to remove the back cover of the display and then unsolder the 10 wires from the four strain gauge sensors. Each of the wires should be labelled to ensure that they can be clearly identified. They can then be terminated to a scrap of matrix board which is mounted on the underside of the scales.

You will need about two metres of 10-way ribbon cable to connect the matrix board to the LCD module. This can be mounted at eye height on your bathroom wall using a couple of small Velcro strips. The ribbon cable can be left to hang down to the bathroom scales on the floor.

**Bathroom scales are cheap to buy but the LCD is attached to the base.**



**The display module is separated from the base and the 10-way ribbon cable connected.**

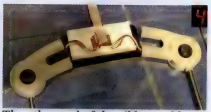
Just don't forget that they are now tethered to the wall display!

The area previously occupied by the LCD behind the glass slab can be taped off to make it look somewhat tidier.

The resulting conversion can be done in an hour or two and even if you want to use it in a bathroom, it is very useful if you need to weigh large parcels or luggage, prior your next flight.

**Poul Kirk,**
**South Guildford, WA. ($50)**

**The leads to the LCD module from the strain gauge sensors must be disconnected.**



**The other end of the ribbon cable is connected to the strain gauge sensors via a piece of veroboard.**

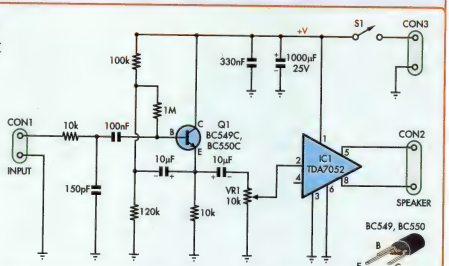
**The display module can now be mounted on the wall at eye height.**

## Guitar practice amplifier has low quiescent current

Low quiescent current for battery-operated equipment is a vital parameter. This makes the TDA7052 a good candidate for a guitar practice amplifier as it has a low quiescent current of 4mA for a 6V supply.

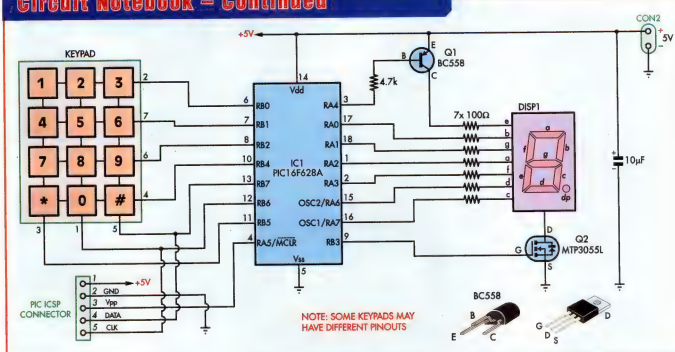
Because it has a bridged output stage, it can deliver up to 1.2W at the supply voltage. It has a fixed gain of 40dB (100) so it only needs a a simple preamplifier to provide adequate gain for use with an electric guitar.

A low-noise BC549 or BC550 transistor is connected as a boot-strapped emitter follower to provide a high input impedance for electric guitars. The 10µF capacitor from the emitter to the junction of the 100kΩ and 120kΩ bias resistors provides the boot-strapping, greatly reducing their loading of the input signal. The input impedance then becomes the 1MΩ bias resistor shunted with the 150pF input capacitor. Hence, the circuit is suitable for inductive or piezoelectric pickups.




The TDA7052 can also be powered from a 12V battery but then the load impedance should be 16Ω or more.

**Petre Petrov,**
**Sofia, Bulgaria. ($45)**




## SudoMate for Sudoku puzzles

When solving a Sudoku puzzle, you need to figure out which digit (1-9) goes into each blank box by a process of elimination. Keeping track of which numbers you have eliminated can be tricky since there is a lot to think about during this process.

This circuit provides an easy solution. It consists of a numeric keypad, a 7-segment LED display, a PIC16F628 microcontroller, three AA cells, two transistors and a few passive components.

In operation, the 7-segment display cycles through digits 1-9 until one of the numbers on the keypad is pressed. That digit is then eliminated from the cycle and this process is repeated until one digit remains. The unit can be reset by pressing the "0" button.

After a period of inactivity, the unit goes into sleep mode and consumes just 70µA. When a key is pressed, it switches back on. The sleep delay can be set by pressing the # (hash) key, then a digit 1-3 (for short, medium or long delay) and then # again.

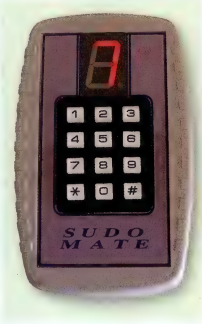
The display brightness is set similarly, using the * (star) key.

Microcontroller IC1 detects key presses using I/O pins RB0-RB2 (pins 6-8) and RB4-RB7 (pins 10-13). The keypad has a matrix arrangement so that when a key is pressed, one of three column pins (1, 3 or 5) is connected to one of the four row pins (2, 4, 6 or 7).

The software enables IC1's internal pull-up resistors for the rows while the pins connected to each column are driven low, one at a time. If a key is pressed when the associated column pin is low, the matching row input on IC1 is pulled to ground. This is sensed by the microcontroller and it can then tell which button was pressed and take the appropriate action.

The 7-segment LED display (DISP1) is a common-cathode type with two LEDs in series per segment (Kingbright RS 235-8597). The common cathode is connected to ground via Mosfet Q2 which is controlled by output RB3 (pin 9) of IC1. This pin has PWM (pulse width modulation) capability and this is used to modulate the brightness of the display. For a brighter display, Q2 is turned on with a higher duty cycle and for a dimmer display, a lower duty cycle.

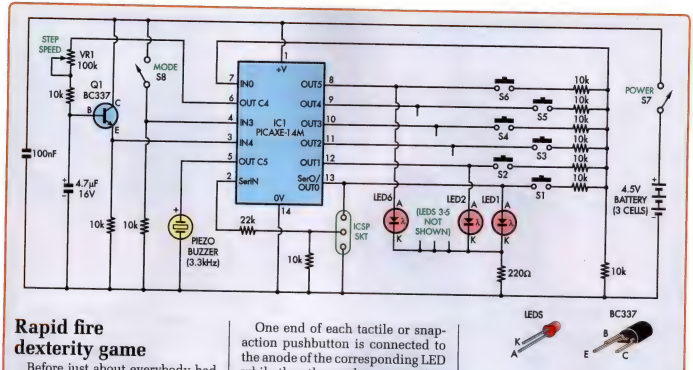
The LED anodes are driven from outputs RA0-RA4 (pins 17-18 & 1-3) and RA6-RA7 (pins 15-16) of IC1. Each anode has a 100Ω series current-limiting resistor, for a nominal LED current of around (4.5V - (1.8V x 2)) ÷ 100Ω = 9mA. The decimal point segment is not used so it isn't connected.




When on, the current for each segment is supplied from the microcontroller's outputs, except for segment "e" which is driven by PNP transistor Q1. This is in turn controlled by IC1's RA4 output (pin 3). This is necessary since RA4 is an open-drain output and can only sink current.

CON1 allows in-circuit serial programming. The software (sudo_628.zip) is available for download from the Silicon Chip website.

**John Western,**
**Hillarys, WA. ($60)**




## Rapid fire dexterity game

Before just about everybody had games on their mobile phones (in fact, before they had mobile phones at all!) you could buy small hand-held games which tested your dexterity. Rapid Fire is a game in that tradition and here is a PICAXE-14M version.

It has two variations but the basic idea is that there are six LEDs which light up one at a time and you need to press the associated button during the time that it is lit to score a point. They can either be lit sequentially or in a pseudo-random pattern and the speed at which the game runs can be adjusted in order to increase the difficulty as you get better at it.

The LED anodes are driven from outputs OUT0-OUT5 (pins 8-13) of IC1, the PICAXE-14M. They have a common cathode and share a single 220Ω current-limiting resistor as only one is lit at a time. This sets the LED current to around (4.5V - 2V) ÷ 220Ω = 11.4mA.

One end of each tactile or snap-action pushbutton is connected to the anode of the corresponding LED while the other end connects via a 10kΩ resistor to pin 7 of IC1 (input IN0). There is also a 10kΩ resistor from IN0 to ground.

If the button corresponding to the lit LED is pressed then the voltage at IN0 will be half the supply voltage (typically 2.25V) and this registers as a "hit". Any other combination of button presses results in a lower voltage and so a hit is not registered. IN0 is operated as an analog input and the precise voltage measured in order to make this distinction.

The software also ignores any button presses which occur immediately upon illuminating the LED, as this means that the button was pressed too early. When a button is pressed at the correct time, scoring a point, the self-oscillating piezo buzzer is briefly powered from output OUT C5 (pin 5) and emits a short beep.

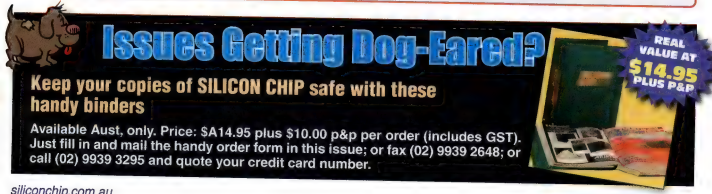
The game speed is adjusted using potentiometer VR1. The 4.7µF capacitor is charged and discharged by output OUT C4 (pin 6) of IC1, via VR1 and a 10kΩ series resistor. The voltage across the 4.7µF capacitor is buffered by NPN transistor Q1 and the associated 10kΩ emitter resistor and fed back to input IN4 (pin 3).

This voltage is then used to determine when to toggle pin 6, forming a relaxation oscillator. It is the rate of this oscillation that determines how fast the game runs.

Mode switch S8 selects between sequential and pseudo-random game modes. Its state is sensed by input IN3 (pin 4) in combination with the associated 10kΩ pull-down resistor. Power comes from three AA or AAA cells, switched by S7.

An on-board programming socket (ICSP) is provided and the software (rapidfire_14m2.bas) is available for download from the SILICON CHIP website.

**Ian Robertson,**
**Engadine, NSW. ($60)**

# Homebrew PCBs via Toner Transfer

By Alex Sum

**Here's a method for the hobbyist to produce near-professional PCBs at home with consistent results. The equipment and materials required are readily available, reasonably priced and well within the capabilities of the average constructor.**

**The most popular way to build** SILICON CHIP electronic projects is from a kit. However, not every project is available as a kit. While project components are generally readily available from component retailers, the PCB is not.

Only recently has SILICON CHIP started selling PCBs and for the most part, they are mainly for recent projects.

And this doesn't help the home constructor who wants to design his own PCB.

## So what to do?

Here's a method of producing near-commercial quality PCBs in either single or double-sided format using an image from a laser printer (*note – inkjet printers are NOT suitable*). The toner from the laser printer is transferred to a blank printed circuit board and used as a resist for standard etchants.

Laser printer toner is mostly plastic particles that when fused makes good etchant resist. There are plenty of articles on the web explaining the theory behind this method and I will not repeat them here.

If you don't have a laser printer but do have access to a laser photocopier, this can usually be used – laser photocopier toner is not too different to laser printer toner, so as long as you can print out a black inkjet copy AND your laser photocopier can handle film (many can't!) you may still be in business.

One other point to watch with both printers and copiers is that some do not give a true 1:1 print or copy. Obviously if the print or copy is distorted (in either direction) it may be useless for this process.

## Required resources

You will need the following:

Obviously, you need the PCB artwork. If it's a SILICON CHIP project, download it from the SILICON CHIP website (www.siliconchip.com.au).

If you are designing your own, you'll need some CAD software for designing PCBs. This is freely available (eg, Autotrax, KiCAD, Eagle, etc), so with the method I describe below, you can easily make PCBs for your own projects as well as SILICON CHIP projects.

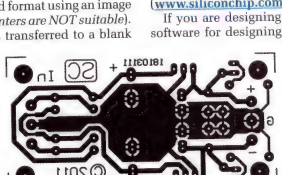


**Fig.1: a typical PCB artwork downloaded from the SILICON CHIP website as a PDF. It has been printed "mirror image" so that it can be used with the Toner Transfer method.**

Access to a laser printer with 600 dpi resolution (or a laser photocopier).

Toner transfer film called "Press 'n' Peel PCB film". It's available from both Altronics (Cat No. H0770) and Jaycar (Cat No. HG9980) as well as other sources. This film has a special coating that

**Fig.2: print the Universal Regulator PCB artwork first onto bond paper, then onto Press'n'Peel film. The arrow helps identify the top side of the paper before printing and also the direction of paper travel through the printer.**

**Fig.3: you can cut blank PCB using a hacksaw and then remove any burrs with a file but I prefer to do it with a router. I made this one and it does the job superbly, with a nice clean cut and no burrs!**

allows printing the PCB track pattern onto the film with a laser printer and then transferring it to the copper surface of a blank PCB.

A cheap A4 laminator (the ones that have synthetic rubber rollers, eg, the GBC brand or similar that retails for under $50.00). This provides both the heat and the pressure to transfer the Press 'n' Peel film image to the blank PCB.

Incidentally, just last month Aldi stores had an A4 laminator on sale for just $16.99 . . .

Suitable etchant and a suitable disposable plastic container to etch in. Ferric chloride etchant is arguably easier to use as it can work at room temperature (and may produce better results). But it is also much messier; ammonium persulphate is much cleaner but requires heating to be effective.

## Steps

### Artwork printout

The first step in making a PCB is to obtain or produce the artwork. The example at left is the Universal Regulator Board (SILICON CHIP March 2011). The PDF file was downloaded from SILICON CHIP website by selecting "Downloads" then the month and finally the project.

As downloaded, this file has the PCB pattern looking at the board from the solder side. Since we have to print this image onto Press 'n' Peel film and then transfer it onto copper side, we need to print it in mirror image.

We also need to ensure that a positive image is printed – that is, the areas of copper are printed black and the areas between tracks (and the holes) are left white.

Most graphics programs will allow you to print a mirror image – that is, as if you are looking through the PCB from the component side (some call it "flipped"). I use Photoshop Elements (a reduced, and much cheaper, version of Adobe Photoshop) to convert the file to mirror image. There are also plenty of downloads on the 'net which will also do this for you. Fig.1 shows this mirrored image.

If you design your own PCB, you should be able to export

**A low-cost commercial laminator provides not only the heat but the pressure needed to transfer the laser printer toner from the Press'n'Peel film to the PCB so it can be etched in the normal way. It may take many passes through the laminator for the toner transfer process to occur.**

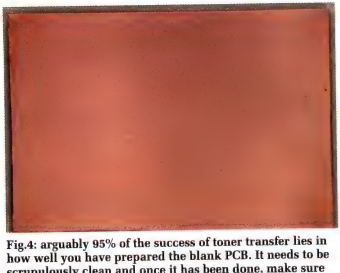


**Fig.4: arguably 95% of the success of toner transfer lies in how well you have prepared the blank PCB. It needs to be scrupulously clean and once it has been done, make sure that there are no fingerprints or dust on the surface.**

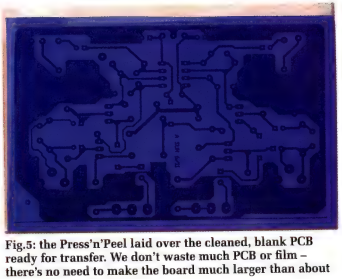


**Fig.5: the Press'n'Peel laid over the cleaned, blank PCB ready for transfer. We don't waste much PCB or film – there's no need to make the board much larger than about 5mm all around.**

the track pattern in mirror image (eg, Autotrax outputs the bottom layer in mirror image by default).

Now you are in a position to print the track pattern onto "Press 'n' Peel" film. First, print out a copy of the track pattern from your laser printer onto standard A4 (bond) paper. The reason for this is you don't want to waste a full sheet of Press-n-Peel, so you need to know where on the paper the image will be printed.

I normally take one sheet of A4 paper and mark on it the top side and direction of paper feed (many printers "flip" the paper as it passes through). I then place this sheet into the manual feed tray of my laser printer and print the PCB image. This is also a good check that the printed size is right, that it is a positive image and that the blacks are black and there is no toner in what should be white or clear.

Next, cut a piece of "Press 'n' Peel" film slightly larger than the actual size of the final PCB (say 3-4mm larger on all sides). Now carefully place this film with the dull side up onto the copy of the printed pattern and with 3M Scotch tape (which is usually unaffected by the heat of the printer) carefully stick the leading edge onto the paper. Place the paper into the manual feed tray again, noting your markings, and print another copy.

You should now have the track pattern printed on the "Press 'n' Peel" film as shown in Fig.2. Ensure that the Press'n'Peel film image has no blemishes or missing toner where you want it.

## Blank PCB preparation

Blank PCB material is available from component retailers in various sizes. I find it more economical to purchase the larger size, 300x300mm (Altronics H0755, Jaycar HP9510). If sourcing it elsewhere and there is a choice, always choose fiberglass PCB over the older phenolic (or SRBP) type. Not only is it better electrically, it's less brittle. Phenolic PCB material has a habit of splitting or shattering.

Cut it to size as required, around 5mm larger than the final size on all sides (for double-sided board, 6-9mm larger on all sides). You can use a fine hacksaw (32 TPI) blade but it's a slow process.

Instead, I use a small router fitted to a homemade router table like the one shown in Fig.3. This setup consists of a piece of 450x300x12mm melamine board with the router mounted upside down at the centre. I use a length of aluminium angle as an adjustable fence. I cut two 7mm wide parallel slots near the left and right edges and with the aid of 6.3mm bolts and wing nuts, I can set the distance of the fence from the router bit. I use a 3.175mm straight bit, so for clearance the diameter of the hole in the centre of the router table can be 6.35mm.

Most small routers designed for edge trimming do not come with speed control. To cut blank PCB, you need to slow the speed right down. I use the SILICON CHIP (February 2009) motor speed controller to set the required speed. I set the router up to cut a depth of just under 1mm and cut the PCB with two passes. This results in minimum breakage of the router bit. I start cutting with the copper side up then flip the board over for the second pass. I use this same setup to cut rectangular holes in ABS boxes for my projects.

Never throw away offcuts of PCB material, even small bits – you never know when you might want to make a board just that size!

After you cut the blank PCB to size, prepare the copper surface. This step is vital; in order for the toner to adhere properly, you need a very clean matt finish on the copper surface like the one shown in Fig.4. I first clean the copper surface with isopropyl alcohol, then scrub the copper surface in random circular motion with a ScotchBrite scourer under running tap water until I get a fine matt finish. A really tarnished board can usually be cleaned with Ajax or similar and Scotchbrite but might need a bit of elbow grease.

I use a clean paper tower to wipe the board dry and from now on, I wear a clean cotton glove whenever I need to handle the board, as oil from skin can stop the toner transfer from working properly.

Once clean, always hold the board by the edges and do not touch the copper surface. And immediately before use, blow the surface of the board with clean air (either an air duster or filtered compressed air) to ensure there are no dust particles on it, nor minute paper particles from the paper towels. Either may affect toner transfer.

## Toner transfer via laminator

Place the printed "Press 'n' Peel" film print side down

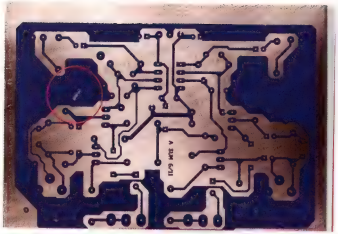


**Fig.6: here's the PCB with the artwork transferred via Press'n'Peel film and the laminator to form a resist. You might notice a couple of blemishes on the board, such as the highlighted scratch top left . . .**

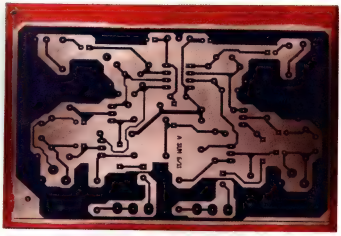


**Fig.7: any blemishes can be repaired with a standard permanent marker pen. If in doubt, touch it up! We've also used a marker pen to mask off most of the blank copper area around the board; it saves both etchant and time.**

onto the copper surface of the board. Try to centre the film so that there is bare copper showing on all four edges, then stick the leading edge to the blank PCB with Scotch tape as show in Fig.5. I sometimes add another piece of Scotch tape on the side as well to keep the film flat on the board.

Allow the laminator to warm up to correct temperature. Most laminators switch on when just warm enough for laminating but leaving it a bit longer may result in a higher temperature (which you want).

Pass the board, leading edge first, with film side up through the laminator as shown in the photo overleaf. The number of passes required depends on board size and ambient temperature and usually is in the order of 25 to 45 passes. The rollers on the laminator provide pressure and heat for the toner transfer process.

Once the copper surface reaches the toner melting temperature, the transfer will take place. You have to experiment and start with, say, 30 passes and increase or decrease the number as required. After a while you will be able to work out what is the optimum number of passes for the various size boards. The board gets very hot after 10 passes or so, therefore you will need to wear cotton gloves to handle it.

Using a laminator, I find that the maximum width of the board you can use without jamming is about 100mm. There is no restriction on the length.

After the board has gone through the required number of passes, allow it to cool down to room temperature. You can now peel off the film and check the board. Sometimes fine dust particles can get between the film and copper surface and will result in tiny holes or tears, especially on the large fill areas as shown in Fig.6. You can fix this easily with a fine "permanent" marker pen (not a whiteboard pen).

I also paint the excess border area of the copper surface with permanent marker (to save etchant and etching time), because that area will be trimmed off later (see Fig.7).

### If you don't have a laminator . . .

Second choice would be a domestic iron, set to non-steam (it's probably a good idea to empty the water out anyway).

Using the hottest setting (usually linen), slowly and methodically iron the toner onto the PCB. This takes a fair bit of practice to get right and even then results can be patchy.

### Etching and drilling

You are now ready to etch the board. I use a disposable rectangular plastic container to hold the etchant.

My preferred etchant is ferric chloride solution (Altronics H0800). You can use ammonium persulphate (Altronics H0802, Jaycar NC4254) if you prefer. Unfortunately, it is more difficult to obtain Ferric Chloride because it cannot be sent through the post, even as powder. Ammonium persulphate, in crystal or powder form, can be mailed.

The major reason I prefer ferric chloride to ammonium persulphate is I find much better edge contrast with ferric chloride. Fig.9 shows two identical boards one etched with ferric chloride, the other with ammonium persulphate, under 40 times magnification. Poor edge contrast with ammonium persulphate is due to bubbles forming during the etch process and eroding the resist.

Another advantage of ferric chloride solution etchant is that it will work at room temperature. However the etching process will be quicker if a warm solution (say 30°C+) is used. Ammonium persulphate will NOT work at room temperature – it must be used at a temperature of 50-80°C (preferably the higher end of the range) so the powder needs to be mixed with hot water immediately prior to etching.

I drill a small hole at the corner of the board and tie a piece of fishing line to it. This allows me to agitate the board when submerged in the etchant (agitation keeps fresh etchant flowing over the copper areas, a "must" to minimise etching time). Usually etching should take between 10 and 25 minutes to complete. Frequent checking will prevent over-etching and undercutting tracks.

During the etching process, you should wear protective clothing and eyewear. Ferric chloride stains are impossible to remove so handle with due care.

Fig.8 shows an etched board with toner still covering the track pattern and ready for drilling. The etched board should be thoroughly cleaned under running water to remove all traces of etchant.

### Re-using etchant

Despite what many references and websites might say,

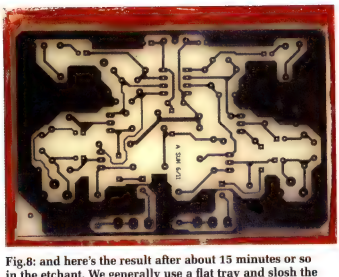


**Fig.8: and here's the result after about 15 minutes or so in the etchant. We generally use a flat tray and slosh the etchant over the board by rocking back and forth. Don't spill ferric chloride – you'll never get the stains out!**

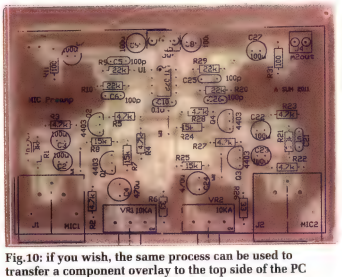


**Fig.10: if you wish, the same process can be used to transfer a component overlay to the top side of the PC board – how professional is that? Remember that the carbon tracks laid down might affect circuit performance.**

etchant can be used again and again. You will know when it is spent because etching times start to blow out significantly. When this happens, the etchant has absorbed as much copper as it readily can and is too weak to be useful.

Used ferric chloride solution should be stored in a sealed bottle (definitely NOT any form of drink or food bottle), clearly marked as used etchant.

Ammonium persulphate can be stored and re-used but as mentioned earlier, needs to be reheated to 80 C+ otherwise it won't etch. That creates something of a problem because you can't heat it in any sort of metal container on the stove!

A friend who also etches PCBs but prefers ammonium persulphate has an old microwave oven in the workshop solely to heat up ammonium persulphate solution (OK, maybe it does heat the occasional cup of coffee).

He rescued it from a council clean-up and repaired it so it cost nothing (it was, as expected, only a high voltage diode that had failed!). If and when it fails from corrosion (almost inevitable when heating etchant), he'll throw it out and find another.

## Etchant disposal

Do not pour spent etchant down the drain. Even if you think it's lost all of its "oomph" it can – and will – attack any metal drain fittings it finds. Given enough time and enough etchant, you will be up for a costly plumbing repair.

Neither should you pour it out on the ground – it is very likely to poison the soil.

I mix spent ferric chloride solution with cement and dispose of it when the cement dries. An alternative in many areas is council-arranged paint and chemical collections.

Spent ammonium persulphate solution is easier to get rid of as it becomes a bright blue copper sulphate solution.

If you let all the water evaporate (it takes some time!), you end up with copper sulphate crystals that can be disposed of quite easily (eg, place in a plastic bag, wrap in newspaper and place in the garbage bin).

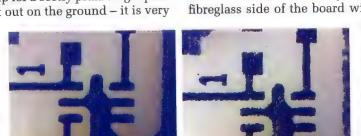


**Fig.9: the reason I prefer ferric chloride etchant, Here is a 40x magnification of the same section of two boards, the one on the left etched with ferric chloride and the one on the right with ammonium persulphate. The right board shows clear signs of undercutting and less precise edges (even though it may well be usable).**

## Drilling

For small holes (0.6 to 1.5 mm), I use a 12V drill with a pin vice chuck. For larger holes I use a small drill press. Small HSS (high speed steel) drill bits are available in hobby shops and component suppliers.

Do not remove the toner until you are ready for soldering, as the toner will protect the tracks and pads from oxidation. You can use fine steel wool to rub off the toner later when you are ready to solder.

Most PCBs are designed with component holes of 0.8mm with larger component lead diameters of 1.0 or even 1.2mm. Mounting holes, screw holes for component tabs etc are generally 3mm. Fibreglass PCBs, though much preferred over the older phenolic type, unfortunately blunt drills much faster so you need to keep a few spares on hand.

## Component overlay

I use the same toner transfer process to put a component overlay on the component side of the board. I print the top overlay in mirror image onto "Press 'n' Peel" film, then use the same method as above to transfer it to the component side of the board. It is likely to take more passes because the fibreglass side of the board will not get anywhere near as hot as the copper side.

Fig.10 shows the component side of the board with the component overlay .

Since Autotrax uses very fine line width for top overlay print out, it is difficult to have 100% complete toner transfer. However, there is enough detail to show component orientation and values. Eagle should do a better job and will be my preferred CAD tool when I finish converting my Autotrax custom library.

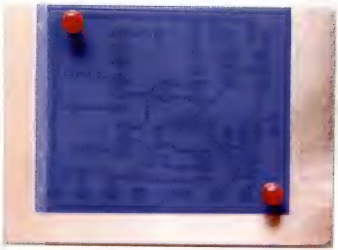


**Fig.11: double-sided board are possible with this system; the only major difficulty is accurate alignment of the two sides. We use the "pins through the board" method and normally make the pads a little larger to compensate.**

A quick spray of circuit board lacquer (Altronics T3086, Jaycar NA1002) will give extra protection for the component overlay.

### Double-sided boards

With some care, you should be able to produce double-sided boards as well. You need extra care when preparing the copper surface to make sure there is no contamination of the surfaces. You will need to print both top and bottom layers onto "Press 'n' Peel" film and cut the blank PCB bigger on all sides, which enables easier alignment of the two pieces of film. You will also need to print out a copy of the drill guide (or drill drawing) onto tracing paper. Place this guide on the blank PCB and tape down with scotch tape as show in Fig.13.

Drill two 0.65mm diameter holes diagonally opposite near the corners. Make sure the drill is at right angles with the board (use a drill press if you have one) and use very fine sand paper to remove any burrs from the two holes.

You can then prepare the copper surfaces for toner transfer. I also make tiny scratches at the corners of the top layer so that I can identify it for placing the correct film later.

Align the top layer film with toner side facing down onto the top layer and use pins to position it over the two holes drilled earlier.

Secure the leading edge of the film with Scotch tape as shown in Fig.11. You can now use a small pin and punch a tiny hole in the centre of the corresponding pads on the bottom layer film. Turn the board over and use the two pins to get the bottom layer film into the correct position as shown in Fig.12.

Once in position, you can secure the leading edge of the film with tape.

After the film is secure, pull out the two pins and the blank board is ready for you to do the toner transfer.

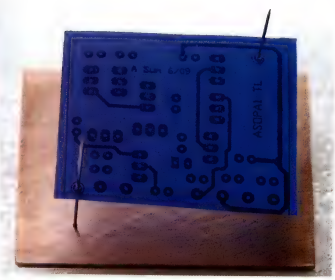


**Fig.12: speaking of pins through the board, here's the opposite side artwork being positioned as close as possible.**

If you are designing your own double-sided board, you may want to make the pads larger (say 20% bigger) as the film alignment method described above may not be 100% accurate.

Commercially made double-sided boards have plated-through holes to electrically connect the top and bottom layers where required (they're called "vias" in PCB-talk); this homemade version obviously does not have these.

Therefore, when the board is finished, you will need to solder some lengths of tinned copper wire between the top and bottom layers for the pads which need to connect to each other. In some cases component leads also need to be soldered to both top and bottom layers.

### Finishing the board

Clean and trim the board to its final size when you are about ready to solder in the components. First trim it with a fine hacksaw then finish off and de-burr with a suitable file. It helps to have the PCB clamped in a vise between two pieces of timber as you cut it.

Clean the toner off the board with fine steel wool and then wipe the board with isopropyl alcohol. Apply a quick spray of circuit board lacquer and allow the board to dry. Circuit board lacquer protects the tracks and pads from oxidation and it contains solder flux to aid soldering.

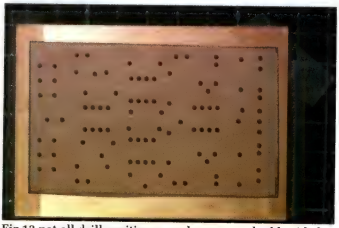


**Fig.13 not all drill positions are shown on a double-sided board so a printout of drill positions and sizes is made and taped to the board before drilling. That way you don't have to keep flipping the board over to get drill positions!**

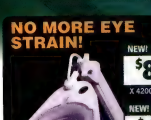
## Conclusion

This method enables the hobbyist to produce prototype quantity PCBs at home with ease.

After some practice, you will be able to make near-professional-quality boards. In fact I make a PCB for all my projects, no matter how simple. SC

# Leap into Altronics!

## NO MORE EYE STRAIN!

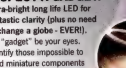


NEW! **$89** X 4200 3 Dioptre

NEW! **$99** X 4201 5 Dioptre

## NEW LED INSPECT-A-GADGET.

**Ultra-bright long life LED for fantastic clarity (plus no need to change a globe - EVER!). Let "gadget" be your eyes. Identify those impossible to read miniature components without straining your eyes. Great for stamp & coin collectors; model makers, jewellers etc.**



SAVE 25% **$25** A 2620

### Compact Portable Mini Mixer

Powered by 9V battery or plugpack (M 9237A $17.95) this tiny mixer is perfect for karaoke or small productions. It mixes four 6.35mm mics. Robust steel case.

SAVE 20% **$22** X 7020

-40°C range. Ideal for cool rooms

### Wireless Desktop Weather Monitor

This compact desk unit measures indoor temperature; outdoor temperature and humidity. -40°C to +65°C. Sensor range 100m. Requires 2 x AA & 2 x AAA batteries.

### Halogens Be Gone!

Switch to long life, low heat, LED for just $25 a lamp. Experience added benefits such as lowered power bills & longer service life. This warm white 5W/240 lumen lamp fits standard MR16 light fittings. Also works with light dimmers!

LIMITED STOCKS

SAVE 36% **$25** X 2232 Warm White

## 1080p HD Sports Action Camera Pack

High definition recording for skydiving, trekking, mountain biking, rock climbing, mountaineering, skiing, snowboarding, motocross, car racing and more!

- Sensor rotates to keep horizon level
- In-built screen • Uses Nokia phone Li-ion batteries (2 included) - recharge via USB • Includes various mounting brackets & straps for helmets, bikes etc.

**$299** SAVE $30

X 0680

Bike helmet for illustration purposes.

| Includes car power charging adaptor | 1080p recording | HDMI output | Water resistant |
|---|---|---|---|

A 2691A

### Redback® 2 x 100W Stereo AM/FM Receiver

Expand your home audio system to the study or entertainment area. Features five stereo RCA inputs, front panel input for iPod, in-built AM/FM tuner and A/B speaker selection. Includes remote control.Size: 430 x 283 x 80mm.

SAVE $50 **$325**

### 6 Stage 12V Weatherproof Battery Charger

Utilises a microprocessor to ensure your battery is in tip-top condition whenever you need it. Diagnoses battery state of charge and delivers an appropriate current.

- Helps to extend the usable lifetime of the battery • Suits permanent connection
- Suits SLA, wet cells, gel cell & AGM batteries - 3Ah to 200Ah. • 14.4V @ 6A max
- Size: 200 x 90 x 45mm.

M 8531

SAVE 15% **$75**

Ideal for the seldom used car, caravan or boat

S 5373

SAVE 35% **$50**

### RFID Keyless Access Pad

Can be set up to require both RFID & keypad access or RFID only. 3 relay outputs; 2 x 3A NC/NO for door strike/alarm triggering, 1A aux.relay. Waterproof case. S 5376 RFID tags $9.15ea. 129Hx84Wx41Dmm.

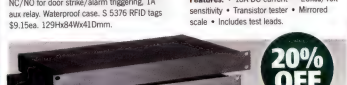
Q 1026

SAVE 22% **$35**

### Analogue Multimeter

Back by popular demand! Ideal for observing constantly varying voltages.

**Features:** • 10A DC current • 20kΩ/Volt sensitivity • Transistor tester • Mirrored scale • Includes test leads.



**20% OFF**

| Type | Part | Normally | Now.. |
|---|---|---|---|
| 1U Raw | H 5011 | $49 | $39 |
| 2U Raw | H 5012 | $59 | $47 |
| 1U Black | H 5031 | $55 | $44 |
| 2U Black | H 5032 | $65 | $52 |
| 3U Black | H 5033 | $79 | $62 |

### Professional 19" Rack Cases

Superb quality finish. Tough powdercoated finish with raw (silver) or black anodised aluminium front. Rear panel is aluminium for easy drilling.

Just like the brand names for a fraction of the price!

### Super-Tough Equipment Cases

IP67 rated for the ultimate dust and water protection for your precious equipment. Ideal for storing test equipment, cameras, computers and sensors. Foam inner can be customised to suit your equipment. Latches can be padlocked. T 5052-65 include shoulder strap. Dimensions are external.

| Size (mm) | Part | Normally | Now.. |
|---|---|---|---|
| 365 x 266 x 185 | T 5050 | $94.95 | $74 |
| 465 x 365 x 185 | T 5052 | $179 | $140 |
| 515 x 435 x 199 | T 5054 | $259 | $199 |
| 650 x 430 x 250 | T 5065 | $479 | $379 |

H 8143

TOP VALUE

SAVE 25% **$50**

### Tilting LCD TV Bracket (32")

Suits a wide range of TV's up to 32" utilising a 200mm VESA mount. Tough powdercoated silver finish. 10° tilt with precise thumbscrew adjustment. Max weight 35kg.

A 3211

NEW! **$99.95**

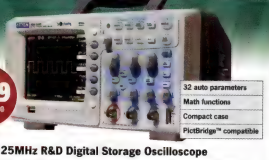
### Component Video & IR Cat5 Baluns

Transmit clear HD component (YPbPr) video, digital audio and infra-red up to 300m over economical Cat 5e/6 cable. Fodel compatible. Includes transmitter, receiver, IR target and emitters & power supply.

# Back To Work Bargains

SAVE 526
$99
Q 1284

**Professional 'Contact Free' Thermometer**
With pin point accurate twin laser guided beam! Provides accurate temperature readings from a distance, ideal for when equipment is operating. ±1% accuracy. 12:1 0.1°C resolution. -35°C to 800°C.



$499
SAVE $100
Q 0200

- 32 auto parameters
- Math functions
- Compact case
- PictBridge™ compatible

**Atten® 25MHz R&D Digital Storage Oscilloscope**
Perfect for those in R&D, product development or service of complex electronic equipment. Features 2 channels with real-time 500MS/s sampling. The colour 5.7" TFT display screen can be set up to simultaneously display the waveform plus indicate the measured wave voltage, peak to peak plus RMS, frequency, duty cycle etc. Realtime adjustments via PC can be made of the scope using included software. Stored data can be saved to a USB stick or downloaded to a PC.

## Computer Bargains

NEW!
$62
D 5507

D 5508
NEW!
$95

**Desktop Hard Drive Docks - USB 3.0 Models**
The easy way to move data from one drive to another. Suits 2.5" or 3.5" SATA hard drives. Enables fast 'hot swapping' of drives whilst the PC is on. A must for IT technicians! Includes power supply, USB3.0 lead & PC backup software.

D 2133
NEW!
$99.95

**Wirless freedom for your PC or laptop!**
2.4GHz wireless keyboard and trackpad. 10m range. Power save mode for extended battery life (includes 2 x AAA).

Wind it up and go!

X 0211
SAVE 20%
$15

**Solar/Dynamo Powered LED Torch**
No batteries required! • Powered by solar panel or wind up dynamo • 3 long life LEDs • Great for camping or fishing • Keep one handy in the glovebox.

NEW!
$11.95
X 0198

**Compact 4 LED Headband Torch**
• 3 white LED • 1 red LED • 3 modes - white light, red light or flashing red • Requires just one AA battery. • So light, you'll barely know you're wearing it!

Suits lead free soldering
2 Year Warranty
All metal case

T 2460
$209
SAVE $50

Great for servicing & re-work

**Micron® 100W Digital Lead Free Soldering Station**
Generates high flip temperatures suitable for lead free soldering (200° to 450°C). In-built power saving mode reduces power consumption and dramatically increases tip life. A high quality ceramic element allows rapid tip heat recovery and consistency. Includes 0.5mm tip. Optional SMD tweezer handles T 2461 ($119).

NEW!
$37.95
D 1634

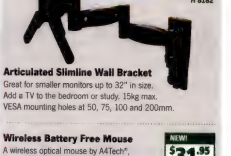
**Extend your USB peripherals up to 50m!**
Great for running keyboard/mouse control across a large room, or from a server rack to your desk. Uses cheap Cat5e cable. USB1.1. See D 1635 for high speed USB 2.0 model.

Add a can of gas for $7.50

T 2599 Kit
SAVE $20
$89

T 2598 Iron Only
SAVE $20
$59

**Iroda® 100W Handyman Gas Tool**
Cordless Go-Anywhere Soldering Iron & Blow Torch. One-click piezo ignition. 2 hours use from a full tank! Available as a tool only, or with full accessory kit. Kit Includes:
• Blow torch tip • Hot knife tip • Hot air tip • Solder • Sponge • Carry case



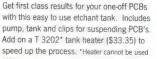
New 200x200 VESA Mount
NEW!
$69
H 8182

**Articulated Slimline Wall Bracket**
Great for smaller monitors up to 32" in size. Add a TV to the bedroom or study. 15kg max. VESA mounting holes at 50, 75, 100 and 200mm.

SAVE 15%
$59
T 5019

**Lockable Aluminium Laptop Case**
Features aluminium panels, reinforced corners for the ultimate protection. Suits up to 17" laptop & accessories. 500x375x90mm.

SAVE 70%
$77
T 3201



**Make your own PCBs & save $$$**
Get first class results for your one-off PCBs with this easy to use etchant tank. Includes pump, tank and clips for suspending PCB's. Add on a T 3202* tank heater ($33.35) to speed up the process. *Heater cannot be used with ammonium persulphate.

SAVE 20%
$16
T 2490

**Pocket Rocket Blowtorch**
One flick of the trigger and you have a whopping 1300°C flame ready for brazing or heatshrinking. Adjustable flame • One handed operation • Safety ignition lock • Refillable gas cartridge.

SAVE 27%
$16

T 2185

**Mini Precision Screwdriver Set**
Ideal for servicing comms & digital devices etc. Features a driver handle & 19 interchangeable, pozi, hex, torx and blade tips.

NEW!
$31.95

**Wireless Battery Free Mouse**
A wireless optical mouse by A4Tech®, which is powered by an inductive pad on your desktop. Never replace batteries again! Features a 2x click button, MS Office shortcuts and scroll functions. D 2086

Follow @AltronicsAU
www.facebook.com/Altronics

**Express Order Hotlines:**
Phone: 1300 797 007
Fax: 1300 789 777
www.altronics.com.au

ALTRONICS
ONE-STOP ELECTRONICS SHOP

# Great Power Savings...

N 1085 85W
SAVE $100
$399

Applications:
Off-road adventurers
Caravans & camping
Boats & yachts

N 1140 140W
SAVE $144
$655

**Backup Solar Power Anywhere, Anytime!**
An excellent backup power source for those off-road adventures or whilst at remote camp sites. In-built 3 stage solar regulator ensures the protection for your batteries and keeps them performing at their peak. Fitted with an adjustable stand to ensure you capture maximum solar energy throughout the day. 4m connection lead.

Includes carry bag.

M 8261 20A
SAVE $30
$129

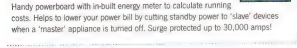
M 8263 30A
SAVE $40
$159

**Powertran® Lab Power Supplies**
These compact, fan cooled, switchmode power supplies deliver up to a huge 30A regulated output; adjustable between 9 and 15V. Plus fixed 13.8V setting. Ideal for comms equipment or servicing. 155x70x205mm.

| Efficiency 85% | Low noise design | Compact metal case | Fan cooled |
|---|---|---|---|

NEW!
$69
P 8159
$95,000 connected equipment warranty!

**Powershield® ZapGuard 8 Way Power Filter**
Surge protection for power, aerial and satellite dish. Great for home theatre & security use. Surge & spike protected up to 110,000 amps with 4090 joules of energy absorption, outperforms many standard surge boards. 5 year warranty.



SAVE 18%
P 8134
$49

**Monitor energy use & cut standby power.**
Handy powerboard with in-built energy meter to calculate running costs. Helps to lower your power bill by cutting standby power to 'slave' devices when a 'master' appliance is turned off. Surge protected up to 30,000 amps!

SAVE 18%
P 8119
$49

**Remote switch your appliances - up to 50m away!**
Control each mains socket from a single remote. Reduce power consumption around the office by turning off idle appliances. Remote includes battery.

HOT SELLER!
SAVE 15%
$36
M 8987A

**3A Multi Voltage Power Pack**
Great for appliances with high current draw such as comms/IT equipment. Voltages: 5, 6, 7.5, 9, 12, 13.5, 15V. Output at 13.5 & 15V settings =2.4A. Includes mains lead.

SAVE 15%
$15
M 8622
Fits in your cars cup holder

**Power up your cup holder!**
Fitted with dual USB sockets & dual accessory sockets. 5V 1A USB output. Keep everything charged up whilst on the road!

Buy two for $20
M 8892
NEW!
$12.95

**Dual USB Mains Adaptor**
With pass through 240V socket so you don't lose an outlet! Great for keeping your phone, tablet or MP3 player charged up.

NEW!
$29.95
S 2695

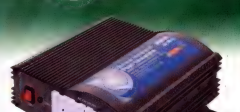
**Rotary Battery Isolator Switch**
Rated to a whopping 1000A (cranking). 200A continuous. Switch between bank 1, bank 2, bank 1& 2 or OFF positions.

SAVE 20%
$9.50
S 4704 2xAAA

SAVE 20%
$15.95
S 4708 2xAA

Great value for money!

**'Ready To Go' Rechargeable Ni-MH Batteries**
Recharge up to 1000 times. Holds up to 85% capacity even when unused for 12 months, ready to go at a moments notice.



M 8012
SAVE $30
$215
Pure sine wave for powering sensitive devices

**300W Pure Sine Wave Inverter - Ideal For 4WD's**
Pure sine wave 12V inverter with high 1000W surge rating suitable for powering difficult loads, including switchmode power supplies. Chassis may be mounted under the car seat. Dual power outlets. 300W continuous rated. Size: 225 x 242 x 80mm.

**Complete Power Protection & Backup**
This Powershield Compuguard UPS unit will prevent damage caused by power fluctuations or blackouts. • 650VA capacity - backup power for 15 min.
• Surge/spike protection • Clean power for valuable equipment
• Phone line spike elimination
• Monitoring & shutdown software

SAVE $10
$109
D 0877A

Power protection for...
Computers | Home Theatre | Security & CCTV Systems

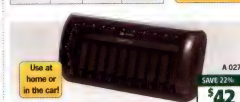
SAVE $20
$89
M 8998

**144W Laptop/Notebook Power Supply**
Top quality replacement power supply. USB output powers peripherals. Includes 9 tips to suit most laptops. Selectable voltages (12-24VDC), max 8.5A. Includes mains lead.

**Premium 12V SLA Batteries**
Great for security, solar power systems, UPS, comms gear etc.

| Capacity | Part | Normally | 2 For... |
|---|---|---|---|
| 1.3Ah | S 5075B | $19.95 | $30 |
| 3.3Ah | S 5080 | $29.80 | $40 |
| 4.5Ah | S 5084 | $27.95 | $48 |
| 7.2Ah | S 5090B | $29.95 | $52 |
| 12Ah | S 5098 | $59 | $90 |

Reliable, long life 12V power for your project!



Use at home or in the car!
A 0276
SAVE 22%
$42

**Charge Up To 12 Batteries At Once**
10 x AA/AAA and 2 x 9V rechargeable overnight battery charger. Keeps plenty of batteries charged for the kids toys! Includes plugpack & car socket adaptor.

# Kits & Projects

### Dual Tracking 0-19V Power Supply Kit

**(SC June '10)** Delivers up to 1.6A from positive & negative outputs with a range of ±0-19V • Adjustable current limiting. • Fixed 5V 750mA output for digital logic ICs and microcontrollers. • Low noise and ripple • Load regulation 0.1%.

### Mini-Maximite BASIC Embedded Module Kit

**(SC November '11)** The 'little brother' of the Maximite kit. Utilising identical software it is designed as an intelligent controller for embedding into larger systems. Features 20 I/O pins, 128K RAM, VGA/composite out, USB2.0 & keyboard interfaces. All from one low cost IC!

## More Great Kit Designs From Silicon Chip...

### 20A Motor Speed Controller Kit

**(SC June '11)** This gutsy little speed controller has a wide range of applications and is simple to build and use. • Low-battery protection • Soft start • Adjustable pulse frequency. • Runs from 12V or 24V batteries at currents of up to 20A.

### 12V Battery Charge Controller Kit

**(SC April '08)** Works in tandem with a power supply or standard battery charger to provide staged float charging for sealed & non-sealed lead acid batteries.

### GPS Boat Computer Kit

**(SC October '10)** Tells you exactly where you are - never get lost at sea again. Also shows speed and heading - plus it will navigate you back home - or to that secret fishing spot! It even displays fuel consumption, along with a host of other vital information.

### Zap Batteries Back To Life!

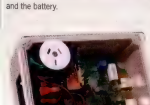
Lead Acid Battery Zapper & Desulphator Kit. **(SC July '09)** Why buy a new battery when you can rejuvenate your current one? This kit can help inject life into car or motorcycle batteries. Connects in-line between the charger and the battery.

### Voice Operated Switch Kit

**Ideal for voice controlled automation projects.**
**(SC July '11).** Triggers relay contacts whenever a sound is made with fully adjustable sensitivity & on-time. Optional manual override. Includes mic insert. Requires 12V DC.

### Remote Control Digital Timer Kit

**(SC August '10)** Switch low voltage devices on/off after set periods. Operated by the included universal remote control. • Trigger inputs • DPDT relay output (30VDC/24VAC - not suitable for mains switching) • Requires M 9237A 9V plugpack $17.95.




### Cut Office Power Consumption

USB Mains Sensing Switch Kit.
**(SC January '09)** Monitors your PC's USB port and automatically turns all your gear on and off as required. No need to crawl under the desk to disconnect devices!

### Smart Fan Controller Kit

**(SC July '10).**
This compact module regulates the speed of up to eight 12V fans. Measures up to 4 temperature points & smoothly controls fan speed. May be monitored using PC software. Ideal for computers, greenhouses, home breweries, amp cooling etc.

### Resurrect Your Old LP's and 78's!

**(SC August '06)** Adds a low noise RIAA phono input to any amp and allows easy line level recording. Prevent the deterioration of your vinyl by converting them to MP3. Can be equalised to suit 45's, 78's & LP's. Requires M 9265A 12VDC plugpack $18.95.

## Sale Ends February 29th 2012

**Altronics One-Stop Electronic Shops Phone 1300 797 007 Fax 1300 789 777**

**Mail Orders: C/- P.O. Box 8350 Perth Business Centre, W.A. 6849**

© Altronics 2011. E&OE. Prices stated herein are only valid for the current month or until stocks run out. All prices include GST and exclude freight and insurance. See latest catalogue for freight rates. All major credit cards accepted.

## Resellers:

**WESTERN AUSTRALIA**

| | |
|---|---|
| Bunbury | ML Communications (08) 9721 9800 |
| Esperance | Esperance Communications (08) 9071 3344 |
| Geraldton | ML Communications (08) 9965 7555 |

**VICTORIA**

| | |
|---|---|
| Beaconsfield | Electronic Connections (03) 9708 9420 |
| Benalla | Leading Edge Electronics (03) 5762 2710 |
| Castlemaine | Top End Technology (03) 5472 1700 |
| Clayton | Rockby Electronics (03) 9562 8559 |
| Cranbourne | Bourne Electronics (03) 5996 2755 |
| Croydon | Truscott's Electronic World (03) 9723 3800 |
| Geelong | Music Workshop (03) 5221 5844 |
| Healesville | Amazon DVDs Healesville (03) 5962 2763 |
| Highett | AV2PC (03) 9555 2545 |
| Leongatha | Gardner Electronics (03) 5662 3891 |
| Melton | Melton Electronics & Comms. (03) 9743 1233 |
| Nunawading | Semtronics (03) 9873 3555 |
| Pakenham | Get Smart HiFi (03) 5941 4886 |
| Preston | Preston Electronics (03) 9484 0191 |
| San Remo | Shoreline Electrical Wholesalers (03) 5678 5361 |
| Somerville | AV2PC (03) 5978 0007 |
| Stawell | David O Jones Mitre 10 (03) 5358 1205 |
| Warrnambool | Multicomm IT & Comms. (03) 5561 5111 |
| Wodonga | Exact Computers & Home Ent. (02) 6056 5746 |

**TASMANIA**

| | |
|---|---|
| Hobart | Active Electronics (03) 6231 0011 |
| Launceston | Active Electronics (03) 6334-7333 |

**QUEENSLAND**

| | |
|---|---|
| Brisbane South | Deisound (07) 3397 8155 |
| Brisbane North | Prime Electronics (07) 3252 7466 |
| Cairns | Pentacom (07) 4032 1710 |
| Clonqurry | Access Electronics (07) 4742 2590 |
| Gold Coast | Prime Electronics (07) 5531 2599 |
| Hervey Bay | Ultra Music (07) 4128 2037 |
| Innisfail | Leading Edge Electronics (07) 4061 6214 |
| Longreach | Access Electronics (07) 4658 5500 |
| Maryborough | Leading Edge Electronics (07) 4121 4559 |
| Rockhampton | Access Electronics (07) 4922 1058 |
| Rockhampton | Home Delivered Computers (07) 4928 2555 |
| Toowoomba | Michael's Electronics (07) 4632 9990 |
| Townsville | Soles (07) 4771 4211 |

**NEW SOUTH WALES**

| | |
|---|---|
| Brookvale | Brookvale Electrical Distributors (02) 9938 4299 |
| Cessnock | Leading Edge Electronics (02) 4990 5971 |
| Cobar | Cobar Electronics (02) 6836 2962 |
| Deniliquin | Wired Entertainment (03) 5881 3555 |
| Gloucester | Autolec Gloucester (02) 6558 1600 |
| Grafton | Downes Electronics (02) 6642 1911 |
| Griffith | Griffith Systems Plus (02) 6964 5933 |
| Gunnedah | Protronics (02) 6742 2110 |
| Lithgow | Leading Edge Electronics (02) 6352 3333 |
| Nth Richmond | Candle Power Technologies (02) 4571 4699 |
| Oak Flats | Oak Flats Electronics (02) 4256 6120 |
| Orange | Fordray Electronics (02) 6362 9901 |
| Penrith | Penrith Light and Sound (02) 4733 3333 |
| Port Macquarie | Fettel Communications (02) 6581 1341 |
| Raymond Terrace | Leading Edge Electronics (02) 4987 4909 |
| Smithfield | Chantronics (02) 9609 7218 |
| Tamworth | Bourke Street Electronics (02) 6766 4664 |
| Taree | Noeledge Systems Pty Ltd (02) 6551 3622 |
| Wagga Wagga | Wagga Car Radio & HiFi (02) 6925 6111 |
| Waterloo | Henkes Electrical Supplies (02) 9319 3133 |
| Wetherill Park | Techtron Electronics Pty Ltd (02) 9604 9710 |
| Wirrdang | Mad Electronics (02) 4297 7373 |
| Wyong | Coastal Caravan and RV Pty Ltd. (02) 4353 1100 |

**SOUTH AUSTRALIA**

| | |
|---|---|
| Adelaide | Aztronics (08) 8212 6212 |
| Brighton | Force Electronics (08) 8377 0922 |
| Enfield | Aztronics (08) 8349 6340 |
| Findon | Force Electronics (08) 8347 1188 |
| Mt Barker | Classic Lights & Electronics (08) 8391 1133 |
| Milton | Leading Edge Electronics (08) 8582 4911 |
| Port Augusta | Spencer Electronics 0407189343 |

**NORTHERN TERRITORY**

| | |
|---|---|
| Darwin | Combined Communications (08) 8942 0644 |

**NEW ZEALAND**

| | |
|---|---|
| Christchurch - Riccarton | Global PC +64 3 3434475 |
| Christchurch - Shirley | Global PC +64 3 3543333 |

# Vintage Radio

By Maurie Findlay, MIEAust.

## The 1930s Palmavox 5-valve superhet; Pt.1

### This is how radio receivers looked in the 1930s

**Housed in a console-style cabinet, the Palmavox is an interesting Australian-made 5-valve superhet AM radio from the early 1930s. However, this particular set had been extensively modified by someone who thought they "knew better" than the original designers.**

IT'S NOT OFTEN that you come across a made-in-the-1930s radio in good condition. But that's just what we have here – this Palmavox receiver looks almost new in its polished wooden cabinet, although it's no longer original and has had quite a lot of work done on it.

The first clue we have to the age of the set is a sticker attached to the base of a type 58 valve. It's marked "Palmers, Park Street, Sydney. Valve is guaranteed until 14.8.34". If we presume that the valve was tested some time after the radio was originally purchased, the set is nearly 80 years old.

While everything outside and inside the set looked original, a close inspection revealed some modifications. Instead of the expected five valves, there were only four valves and two coil cans on the chassis. I also found two hand-drawn schematic diagrams, one for a 5-valve superhet and another for a 4-valve TRF. Someone had modified and simplified the original design!

But why would anyone do this? To understand their motivation, we need to delve into the circuit.

The original design used an "autodyne" frequency converter with a type 57 valve. This arrangement was used at a time when radio valves were very expensive and in the case of domestic sets, allowed a superhet circuit to be designed with one less valve than used in costly professional models.

### Marginal operation

There was one potential problem though – the oscillator function of the autodyne was sometimes marginal, being dependent on the quality of the coils and the amplifying ability of the valve. As a result, it's possible that the original owner just wasn't able to get the oscillator to work and so decided to convert the set to a simpler TRF (tuned radio frequency) arrangement. He may not have fully realised just how poor the performance of the set would be with one less valve and no IF (intermediate frequency) amplifier stage with its superior selectivity.

Both the original hand-scribbled circuits have been redrawn and are reproduced here. Bearing in mind their origins, neither of them may be completely accurate. My immediate aim was to check out the power supply, the audio amplifier and loudspeaker. Then, a little further down the track, my aim is to convert it into a much better-performing radio with a frequency converter and IF amplifier stage, much like the original circuit.

Not surprisingly, it's no longer possible to obtain original spare parts and that includes the oscillator coil and one of the IF transformers. That

**The chassis is bolted to a shelf inside the timber cabinet, while the electrodynamic loudspeaker is mounted on a heavy wooden baffle immediately below. The baffle isn't original though – it's made of chipboard, a material that didn't exist in the 1930s. The grille cloth has been changed as well.**

means that suitable substitutes will have to be found.

The previous owner did a beautiful job of restoring the metal chassis by filling in the holes left by the valve socket and the two coil cans he removed. Metal pieces have been soldered into the holes, the gaps filled and the outside of the chassis repainted. Only by close inspection can these mechanical repairs be seen.

It would be a pity to undo this workmanship, so when restoring the receiver to the original circuit my plan is to mount the converter valve and other components underneath the chassis, where they won't be seen. Hence the Palmavox will end up as a questionable mixture of 80-year-old and more recent technologies but to anyone looking into the rear of the cabinet, it will look original . . . almost!

## 1920s-1940s radios

To understand the Palmavox better, let's take a look at the way radios were made in the 20 years from 1920-1940. During that period, valve technology reigned supreme and the semiconductor technology we now take for granted hadn't even been dreamed about.

Although the idea of the "supersonic heterodyne" (or superhet) receiver was by then well-known, most domestic radio receivers made in the 1920s relied on front-end amplifiers and circuits that were tuned to the frequency of the incoming signal. These sets were referred to as tuned radio frequency (or TRF) receivers. They used less valves and so were cheaper to build than superhet receivers, although their performance was somewhat inferior.

During that period, experimenters often assembled radios from kits. These often used a feedback system (known as regeneration) which allowed the user to adjust the front-end so that it was on the verge of oscillation, thus gaining a big increase in both amplification and selectivity. This meant that users had to be technically inclined to get the best out of such sets. And if a set was allowed to go into oscillation, it could radiate

### The Terms Explained

**TRF:** Tuned Radio Frequency – a radio receiver with all the selective circuits tuned to the incoming signal frequency.

**Superhet:** short for "supersonic heterodyne" – a radio circuit that converts the incoming signal to another frequency (ie, the intermediate frequency), with advantages in gain and selectivity. The intermediate frequency (or IF) is usually lower than the signal frequency and, during the 1920s, could be as low as 30kHz. Modern AM medium-wave receivers have an IF of 455kHz or 450kHz, while 10.7MHz is used for FM.

**Autodyne:** a circuit arrangement, usually based on a pentode, which combines the functions of frequency changer and local oscillator into one valve. It was commonly used in superhet receivers before special converter valves were developed.

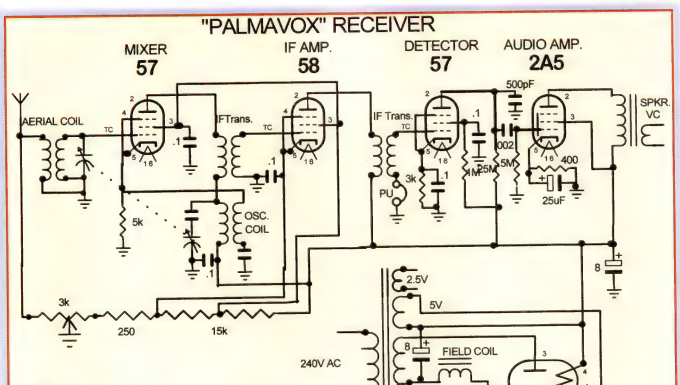



**Fig.1 (above): the original circuit of the Palmavox receiver. It's a good example of early superhet design, with an autodyne mixer and an anode-bend detector but no AGC. Note the volume pot across the aerial coil primary winding.**

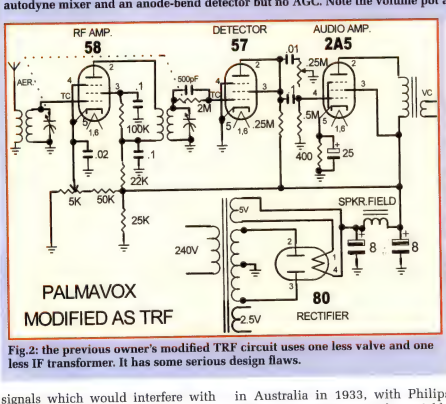



**Fig.2: the previous owner's modified TRF circuit uses one less valve and one less IF transformer. It has some serious design flaws.**

signals which would interfere with other radios nearby.

## Valve manufacture

Amalgamated Wireless Valve Co (AWV) began manufacturing valves in Australia in 1933, with Philips following in early 1936. This quickly brought down the cost of valves and so superheterodyne circuits became the standard for domestic radios produced from the mid-1930s onwards.

Although some indirectly-heated valves with 2.5V filaments were produced locally, the introduction of car radios quickly established 6.3V as the standard (ie, the voltage of a fully charged 3-cell lead-acid accumulator). The late 1940s also saw the development of miniature directly-heated 7-pin valves, some with filaments designed to operate from 1.5V dry cells. The latter made battery-operated portable radios a practical proposition for the first time.

As shown in Fig.1, the original Palmavox circuit used several different valve types. These included two 57s (mixer and detector), a 58 for the IF amplifier, a 2A5 audio output stage and an 80 rectifier.

The type 57 has a screen grid and a 2.5V heater and is suitable for both radio and audio frequency amplification. The inner control grid (connected to a cap on the top of the glass envelope) is wound as a continuous fine wire helix, giving the valve a "sharp cut-off" characteristic. It was replaced in the 1930s by the 6.3V 6C6 and 6J7 types and later by the octal-based 6J7G, all with similar characteristics.

The 58 also featured a 2.5V heater and was similar to the 57 except that the inner control grid helix was wound with a varying pitch. This gives the valve a "remote cut-off" characteristic. As the negative bias on the grid increases, the valve's amplification decreases, thus providing a simple way of controlling gain. The 58 was later replaced with the 6.3V 6D6 and 6U7G types.

The 7-pin miniature valve series developed in the late 1940s featured much higher gain, thanks mainly to improved manufacturing techniques. In particular, the 6AU6 is a sharp cut-off type and the 6BA6 a remote cut-off version, these valves doing similar jobs to the original 57 and 58 respectively.

## Palmavox circuit

The original autodyne circuit used in the Palmavox receiver has a few puzzling design features – see Fig.1.

First, the 5kΩ resistor in the cathode circuit of the 57 mixer valve would result in a low plate current and so the gain of this stage would be quite low. In addition, this 5kΩ resistor is in parallel with the feedback winding of the oscillator coil assembly and so it would provide a high degree of damping.

Perhaps if the previous owner had simply removed this 5kΩ resistor and installed a lower-value resistor in parallel with the series capacitor in the feedback winding, the 57 would have worked fine as an autodyne converter. It would then have been completely unnecessary to downgrade the set to a TRF receiver.

An IF transformer is used to couple the 57's output to the following 58 IF amplifier stage. The hand-drawn circuit doesn't show tuning capacitors but they would certainly have been present, along with trimmers so that the circuit could be tuned exactly to the IF. The screen of the 58 is operated at about 100V in parallel with the screen of the mixer and the gain is controlled by a 3kΩ potentiometer in the cathode circuit.

**The chassis in good condition but some of the parts, including a 57 valve and an IF transformer, are missing due to its conversion to a simpler TRF circuit.**

A second IF transformer couples the IF amplifier's output into the grid of the 57 detector/amplifier valve. Here I would have expected the 57's cathode resistor to be higher than 3kΩ in order to provide linear detection. However, provision is also made for connecting a pick-up into the grid via the IF transformer so it's possible that the 3kΩ resistor was chosen as a compromise between radio performance and phonograph performance. After all, why worry about a little distortion!

A type 2A5 pentode is used as the audio amplifier and this drives a loudspeaker via an output transformer. This circuit is quite conventional except that the 400Ω cathode resistor is a little higher than usual. The 2A5 was later replaced by the octal-based 6F6G (6.3V) and following that by the 6V6G beam tetrode.

## Power supply

The AC secondary from the power transformer is fed to a type 80 rectifier. This valve has a directly-heated 5V filament which is supplied by a separate winding on the transformer. This valve was superseded by the

**There is plenty of room under the chassis. Two holes at top left have been filled in by the previous owner, while the two large holes at bottom right originally accommodated the HT filter capacitors. Note the knot used to "anchor" the mains cord – a technique that's unsafe and completely unacceptable today.**

octal-based 5Y3G which has exactly the same electrical characteristics.

The power supply circuit also shows the loudspeaker's "field-coil". Basically, loudspeakers in the 1930s used a field coil as an electromagnet instead of employing a permanent magnet as used in modern speakers. This usually had a resistance of 1-2kΩ and also served as a filter choke for the HT line.

As a result, the power transformer's secondary voltage had to be higher to make up for the voltage drop across the field coil. A common value was 385V either side of the centre tap.

Because the 80 rectifier heats up faster than the other valves, there is a short period when the HT (high-tension) voltage is higher than normal. This must be taken into account when replacing the electrolytic filter capacitors. A rating of around 550V is desirable and such capacitors are difficult to obtain these days.

However, it is possible to buy filter capacitors with a value up to about 47μF and rated at 400V working. Two of these can be placed in series to exceed the voltage requirement but resistors should also be placed in parallel with each capacitor in case they have different leakage currents.

In the case of the Palmavox, two 10μF capacitors in series from the filament of the 80 rectifier to the transformer centre-tap and two 47μF capacitors in series across HT supply could be substituted for the original 8μF capacitors. These would reduce the 100Hz hum to a reasonably low level. A 100kΩ 1W resistor should be placed in parallel with each of these capacitors.

Note that in this circuit, the field coil is in the negative return of the HT line (ie, between the transformer's centre tap and ground). That's a little unconventional – in most circuits, the field coil is in series with the positive line, with the filter capacitors on either side.

## Modified circuit

Fig.2 shows the modified TRF circuit. Unfortunately, the person who carried out these modifications made a number of serious errors, the worst of which was to abandon the original design in the first place!

In the modified circuit, the 58 has been used as a tuned RF amplifier. Its plate is coupled to the 57 detector via the original second IF transformer. The tuning capacitors had been removed from both IF windings and the second section of the tuning-gang connected across the secondary winding. As it happens, the inductance of the secondary is less than that of the aerial coil, so the circuit is tuned to a higher frequency.

The 57 valve is wired as a "leaky grid" detector which is effectively a diode directly coupled to a triode. The original plate detector would have provided greater amplification.

The end result is a receiver which is so insensitive that it needs a very long antenna to receive anything at all. It also lacks selectivity which means that two stations may be heard at the same time.

The power supply has also been modified, with the speaker field coil now in series with the positive line of the HT supply. This works OK but the original circuit has an advantage in that the voltage between the speaker frame and field coil is lower.

## Proceed with caution

The changes made to this circuit were both unnecessary and badly executed. My advice to people restoring historical radio equipment is not to make any major changes unless you are fully confident about the undertaking. Unfortunately, the previous owner of the Palmavox had enough knowledge to trace out circuit diagrams but no real understanding of how they worked.

The old saying "a little knowledge is a dangerous thing" certainly applies here.

My next job is to restore the set to a fully-functional version, while retaining the original circuit ideas and appearance as far as possible. SC

# WIRELESS DESIGN

## TEST AND MEASUREMENT

### RF COMPONENT SUPPLY

-Attenuators -Connectors
-Filters -Cable Assemblies
-Duplexers -Couplers

### RF EQUIPMENT RENTAL

-Sitemasters -RF Power Amplifiers
-Cellular BTS analysers -PIM Testers
-RF Spectrum Analysers -RF Network Analysers

### RF CALIBRATION

-Sitemasters -Signal Generators
-Network Analysers -Power Meters
-Spectrum Analsyers -DC to 40 GHz

### RF CONSULTING

-Receiver Design -EMC
-Cellular Coverage -Passive Intermod
-Cable Analyser Training

### RF TEST EQUIPMENT SALES - NEW AND USED

-Kaelus PIM Testers -HP 8920 Test Sets
-RF Power Meters -RF Sig Gens 40 GHz
-Cable Analysers -Network Analysers

### EMC EQUIPMENT RENTAL

-RF Immunity Radiated -Fast Transients
-RF Immunity Conducted -RF Emissions
-ESD -Burst Tests

www.wirelessdesign.co.nz
sales@wirelessdesign.co.nz
phone 0276116053 (+64276116053 overseas)



# Signal Hound

## USB-SA44B Spectrum Analyzer
## Measuring Receiver

1Hz to 4.4GHz

- The perfect tool for general lab use, electronic engineering students, ham radio enthusiasts, and electronic hobbyists alike.
- Phase noise, harmonics, and modulation measurement utilities included.
- Automated test capabilities using API.
- Standard operating temperature range of 0°C to +70°C and optional extended temperature range of -40°C to +85°C.

www.SignalHound.com

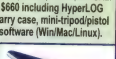


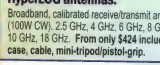
# AARONIA AG

Made in Germany; 10 year warranty

**RF Spectrum Analysers:**
2.5 GHz, 4 GHz, 6 GHz, 8 GHz, 9.4 GHz. **From only $660 including HyperLOG antenna, carry case, mini-tripod/pistol grip, MCS software (Win/Mac/Linux).**

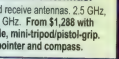
**HyperLOG antennas:**
Broadband, calibrated receive/transmit antennas (100W CW). 2.5 GHz, 4 GHz, 6 GHz, 8 GHz, 10 GHz, 18 GHz. **From only $424 including carry case, cable, mini-tripod/pistol-grip.**





**HyperLOG X active antennas:**
Active, calibrated receive antennas. 2.5 GHz, 4 GHz, 6 GHz, 8 GHz. **From $1,288 with carry case, cable, mini-tripod/pistol-grip. Optional laser pointer and compass.**

**USB RF Spectrum Analysers:**
6 GHz, 8 GHz, 9.4 GHz. **From $1,131 including OmniLOG antenna, carry case, MCS spectrum analysis & logging software (Win/Mac/Linux).**



**Order online at... www.measurement.net.au**

**Tel: 1300 726 550**

Measurement Innovation Pty Ltd

Screening EMC Antennas | AARONIA AG | EMC Testequipment Spectrum Analyzer



# JOIN THE TECHNOLOGY AGE NOW WITH PICAXE

Developed as a teaching tool, the PICAXE is a low-cost "brain" for almost any project. Easy to use and understand, professionals & hobbyists can be productive within minutes. Free software development system and low-cost in-circuit programming. Variety of hardware, project boards and kits to suit your application. Digital, analog, RS232, 1-Wire™, SPI and I²C.PC connectivity.

NEW PICAXE Shield kits now in stock!

**Applications include:**

- ☑ Datalogging
- ☑ Robotics
- ☑ Measurement & instruments
- ☑ Motor & lighting control
- ☑ Farming & agriculture
- ☑ Internet server
- ☑ Wireless links
- ☑ Colour sensing
- ☑ Fun games

**Distributed in Australia by**

**Microzed Computers Pty Ltd**

**Phone 1300 735 420 Fax 1300 735 421**

**www.microzed.com.au**

# SILICON CHIP REFERENCE BOOKSHOP

## PROGRAMMING and CUSTOMIZING THE PICAXE By David Lincoln (2nd Ed, 2011)

A great aid when wrestling with applications for the popular PICAXE series of microcontrollers. Works at beginner, intermediate and advanced levels. Every electronics class, school and library should have a copy, along with anyone who works with PICAXEs. See the review in April 2011 SILICON CHIP.
300 pages in paperback

## SMALL SIGNAL AUDIO DESIGN

By Douglas Self – First Edition 2010

The latest from the Guru of audio. Explains audio concepts in easy-to-understand language with plenty of examples and reasoning. Inspiration for audio designers, superb background for audio enthusiasts and especially where it comes to component peculiarities and limitations. 558 pages in paperback Expensive? Yes. Value for money? YES! Highly recommended.

## PROGRAMMING 32-bit MICROCONTROLLERS IN C By Luci di Jasio (2008)

Subtitled Exploring t he PIC32, a Microchip insider tells all on the newest, most powerful PIC ever! Condenses typical introductory "fluff" focusing instead on examples and exercises that show how to solve common, real-world design problems quickly. Includes handy checklists.
FREE CD-ROM includes source code in C, the Microchip C30 compiler, and MPLAB SIM.
400 pages paperback.

## TV ACROSS AUSTRALIA

Edited by Kaz Bielecki – 4th Edition 2007

The Grey Army's "Bible"! Travelling around Australia? Want to know where to point the antenna? This has the channels, polarity and location of all analog television transmitters and translators from coast to coast. (Any digital TV services are usually co-sited). Plus coverage maps, analog tv transmitter data . . . for the first time, everything you need to know in the one place!

***LAST FEW COPIES – SAVE WHILE THEY LAST . . . NOW ONLY $29.95***

## PIC IN PRACTICE by D W Smith.

2nd Edition - published 2006

Based on popular short courses on the PIC, for professionals, students and teachers. Can be used at a variety of levels. An ideal introduction to the world of microcontrollers. 255 pages in paperback.

## PRACTICAL GUIDE TO SATELLITE TV

By Garry Cratt – Latest (7th) Edition 2008

Written in Australia, for Australian conditions by one of Australia's foremost satellite TV experts. If there is anything you wanted to know about setting up a satellite TV system, (including what you can't do!) it's sure to be covered in this 176-page paperback book.

## PIC MICROCONTROLLERS: know it all

Multiple authors

The best of subjects Newnes authors have written over the past few years, combined in a one-stop maxi reference. Covers introduction to PICs and their programming in Assembly, PICBASIC, MBASIC & C. More than 900 pages in paperback.

## NEWNES GUIDE TO TV & VIDEO TECHNOLOGY

By KF Ibrahim 4th Edition (Published 2007)

It's back! Now in a new edition provides a full and comprehensive coverage of video and television technology including HDTV and DVD. Starts with fundamentals so is ideal for students but covers in-depth technologies such as Blu-ray, DLP, Digital TV, etc so is also perfect for engineers. 600+ pages in paperback.

## PIC MICROCONTROLLER –YOUR PERSONAL INTRODUCTORY COURSE

By John Morton 3rd edition 2005.

A unique and practical guide to getting up and running with the PIC. It assumes no knowledge of microcontrollers – ideal introduction for students, teachers, technicians and electronics enthusiasts. Revised 3rd edition focuses entirely on re-programmable flash PICs such as 16F54, 16F84 12F508 and 12F675.
226 pages in paperback.

## RF CIRCUIT DESIGN

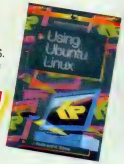
by Chris Bowick, Second Edition, 2008.

A new edition of the classic RF circuit design book. RF circuit design is now more important that ever in the wireless world in which we live. In most of the wireless devices that we use there is an RF component – this book tells how to design and integrate in a very practical fashion. 244 pages in paperback.

## USING UBUNTU LINUX

by J Rolfe & A Edney – published 2007

Ubuntu Linux is a free and easy-to-use operating system, a viable alternative to Windows and Mac OS. Introduces Ubuntu, tells how to set it up, covers the various Open Office applications and gives troubleshooting hints and tips.
Highly recommended.
222 pages in paperback



## OP AMPS FOR EVERYONE

By Carter & Mancini –NEW 3RD EDITION!

Substantially updates coverage for low-speed and high-speed applications, and provides step-by-step walk-throughs for design and selection of op amps. Huge 648 pages!

# 10% OFF!

**WANT TO SAVE 10%? SILICON CHIP (PRINT EDITION) SUBSCRIBERS* AUTOMATICALLY QUALIFY FOR A 10% DISCOUNT ON ALL BOOK PURCHASES!**

(*Does not apply to website orders)

See the handy order form elsewhere in this issue!

## WOW! WHAT AN OFFER!

**SILICON CHIP'S PERFORMANCE ELECTRONICS FOR CARS AND SILICON CHIP'S ELECTRONIC PROJECTS FOR CARS Vol 2 – BOTH BOOKS TOGETHER AT A VERY SPECIAL PRICE!**

Here's sensational value: PERFORMANCE ELECTRONICS FOR CARS (was $19.80) and ELECTRONIC PROJECTS FOR CARS VOL 2 (Originally $12.95) at a huge saving. While stocks last (they're getting low) and some might be slightly shop soiled – but just look at the saving! Get more performance, more projects for your car and $AVE!

**$15.00**

## AC MACHINES

By Jim Lowe Published 2006

Applicable to Australian trades-level courses including NE10 AC Machines, NE12 Synchronous Machines and the AC part of NE30 Electric Motor Control and Protection. Covering polyphase induction motors, single-phase motors, synchronous machines and polyphase motor starting. 160 pages in paperback.

**$66**

See Review March 2010

**$81**

## AUDIO POWER AMPLIFIER DESIGN HANDBOOK

by Douglas Self NEW 5th Edition 2009

The latest edition of "the Bible" on audio power amplifiers. Many revisions and updates to the previous edition and now has an extra three chapters covering Class XD, Power Amp Input Systems and Input Processing and Auxiliarly Subsystems. Not cheap and not a book for the beginner but if you want the best reference on Audio Power Amps, you want this one!

463 pages in paperback.

## DVD PLAYERS AND DRIVES

by K.F. Ibrahim. Published 2003.

A guide to DVD technology and applications, with particular focus on design issues and pitfalls, maintenance and repair. Ideal for engineers, technicians, students of consumer electronics and sales and installation staff. 319 pages in paperback.

As reviewed in SILICON CHIP February 2004.

**$71**

NEW LOW PRICE!

## PRACTICAL VARIABLE SPEED DRIVES AND POWER ELECTRONICS

by Malcolm Barnes. 1st Ed, Feb 2003.

An essential reference for engineers and anyone who wishes to design or use variable speed drives for induction motors. As reviewed in SILICON CHIP September 2003. 288 pages.

**$73**

## SELF ON AUDIO

by Douglas Self 2nd Edition 2006

A collection of 35 classic magazine articles offering a dependable methodology for designing audio power amplifiers in a way that improves performance at every point without significantly increasing cost. Includes compressors/limiters, hybrid bipolar/FET amps, electronic switching and more. 474 pages in paperback.

**$69**

## ELECTRIC MOTORS AND DRIVES

By Austin Hughes - Third edition 2006

Brand new edition of this amazingly popular book. Intended for non-specialist users of electric motors and drives, filling the gap between academic texts and general "handbooks". Explores all of the widely-used modern types of motor and drive including conventional & brushless DC, induction motors, steppers, servos, synchronous and reluctance. 384 pages, soft cover.

**$51**

## PRACTICAL RF HANDBOOK

by Ian Hickman. 4th edition 2006

The latest guide to RF design for engineers, technicians, students and enthusiasts. Covers key topics in RF: analog design principles, transmission lines, couplers, transformers, amplifiers, oscillators, modulation, transmitters and receivers, propagation & antennas. 279 pages in paperback.

**$61**

## SWITCHING POWER SUPPLIES A to Z

by Sanjaya Maniktala. Published 2006.

Theoretical and practical aspects of controlling and measuring electromagnetic interference in switching power supplies. Includes flow-charts for building DC-DC converters and their magnetic components under typical wide-input supply conditions.

503 pages in hard cover.

NEW EDITION DUE SHORTLY!

## BUILD YOUR OWN ELECTRIC MOTORCYCLE

**$40**

by Carl Vogel. Published 2009.

Alternative fuel expert Carl Vogel gives you a hands-on guide with the latest technical information and easy-to-follow instructions for building a two-wheeled electric vehicle – from a streamlined scooter to a full-sized motorcycle. 384 pages in soft cover.

## RADIO, TV AND HOBBIES April 1939 to March 1965

**– Every article to enjoy once again on DVD-ROM!**

This remarkable archival collection spans nearly three decades of Australia's own "Radio and Hobbies"/"Radio TV and Hobbies". Every article has been scanned into PDF format – ready to read at your leisure on your computer (obviously, a computer DVD-ROM reader is required along with Acrobat Reader 6 or later). For history buffs, it's worth its weight in gold. For vintage radio enthusiasts, what could be better? For anyone interested in electronics, this is one which you MUST have in your collection! NB: Does not play on audio DVD players.

**$62**

## THE AMATEUR SCIENTIST CD

***Latest version – V4.***

Many thousands of copies now sold. An incredible CD containing over 1000 classic projects, sourced from Scientific American over the past 73 years – covering every field of science. Very latest edition, just out. Suits ages 12 to adult and runs with any browser (on Win2000 or later). Recommended by the US National Science Teachers Assn.

**$62**

**NOTE: ALL PRICES ARE PLUS P&P – *AUSTRALIA ONLY: $10.00 per order;* *NZ – $12.00 PER BOOK;* *REST OF WORLD $18.00 PER BOOK***

**To Place Your Order:**

**eMAIL (24/7)** silicon@siliconchip.com.au with order & credit card details

**OR**

**FAX (24/7)** Your order and card details to (02) 9939 2648 with all details

**OR**

**PAYPAL (24/7)** Use your PayPal account *silicon@siliconchip.com.au*

**OR**

**PHONE - (9-5, Mon-Fri)** Call (02) 9939 3295 with your credit card details

**OR**

**MAIL** Your order to PO Box 139 Collaroy NSW 2097

**Or use the handy order form elsewhere in this issue**

*ALL TITLES SUBJECT TO AVAILABILITY. PRICES VALID FOR MONTH OF MAGAZINE ISSUE ONLY. ALL PRICES INCLUDE GST

# ASK SILICON CHIP

**Got a technical problem? Can't understand a piece of jargon or some technical principle? Drop us a line and we'll answer your question. Write to: Ask Silicon Chip, PO Box 139, Collaroy Beach, NSW 2097 or send an email to silicon@siliconchip.com.au**

## Old Mosfet amplifier now obsolete

I'm proud to say that my Playmaster Mosfet Amplifier featured all those years ago in *Electronics Australia* magazine has just celebrated its 30th birthday. It hasn't missed a beat in all that time and still sounds pretty good to me. I think the only thing I've had to do was flush out the pots with some contact cleaner on one or two occasions over the years.

I've just updated my speakers and have noticed an annoying audible "pop" when the amplifier is turned off. I reconnected my old speakers and can hear the "pop" from them as well, albeit at a slightly lower level.

The speaker protection circuit is functioning OK. At power-up, there is a delay before the relay energises and at turn-off it de-energises quickly as per design. The audible "pop" is instantaneous with the throw of the power switch.

The DC voltage at the speaker outputs is less than 3mV on each channel, so no apparent issue there. (D. W., via email).

● It's almost impossible to nominate what might be causing the "pop" after all these years. You might try replacing the .01µF 2kV capacitor across the power switch, as it may have gone open circuit. And while it is pleasing that the amplifier is still going after 30 years, we should state that its performance is quite mediocre compared to SILICON CHIP amplifiers of the last 10 years or so.

## Temperature controller for a toaster oven

Would you consider a project for a temperature controller to convert a toaster oven into a SMD reflow soldering oven? I envisage that it could be done with a microcontroller and a MAX6675 Thermocouple-to-Digital Converter chip and using a Triac to control the AC supply to the elements.

Commercial ovens can cost hundreds of dollars and this could be a good use to recycle an old oven. (T. B., via email).

● Good suggestion but it is not just a matter of maintaining a particular temperature. We had an article on this topic in the March 2008 issue, where Jim Rowe showed how to use a toaster oven for reflow soldering.

## Ignition repair on a Ferguson tractor

I recently assisted a friend to repair the ignition system on a Ferguson tractor which has a positive earth electrical system. The ignition coil had failed and a new "modern" one was purchased which is designed for vehicles with negative earth.

Is there a difference in ignition coils designed for the different earthing systems? If you have to use a modern coil, is it best to retain the modern connections, that is the negative terminal goes to the points, even if this means the polarity at the spark plug is incorrect? (G. P., via email).

● The most important aspect of your question has probably already been answered: presumably, it worked.

Using a negative earth coil in a positive earth vehicle is not ideal, since autotransformer action in the ignition will subtract rather than add the primary voltage to the secondary voltage. Also, the spark polarity may be incorrect, leading to possibly reduced reliability of mixture ignition.

However, if the repair worked and you cannot obtain the original coil then these objections are more or less academic.

## Station settings should not be lost

I have an Akai stereo system that I got nearly 15 years ago. Every time we had a power blackout or the stereo was switched off at the wall, all the radio stations would be erased from the memory. A stereo that I got a few years later managed to stay programmed

## Using The Input Selector Board To Switch Video

Is it possible to use a second input selector board from your latest preamp (SILICON CHIP, January 2012) to switch video? That is, just "daisy-chain" the ribbon cable and only equip either the left or right channel with sockets? (C. H, via email).

● This may well be be feasible. We are not sure how good the video quality would be but it may be OK. There would need to be some changes to the components installed:
(1) The 100Ω resistors in series with the signal on the video switcher board should be replaced with links.
(2) The 470pF capacitors at the output connectors should be omitted.
(3) The ferrite beads can probably stay although it's possible they will make the display a little blurry. If so you could try taking them out.
(4) The six 2.2kΩ resistors shown near CON9 on the circuit diagram for the relay board (Fig.3) should be omitted although it will probably function if they are left in. The other 2.2kΩ resistors must be installed.
(5) The 5V regulator on the main preamp board will probably require a small flag heatsink to deal with the extra dissipation due to the current drawn by the extra relay (30mA).
(6) The two relay boards can be connected to the preamp board using a longer ribbon cable with an extra IDC connector in the middle. This would need to have the same orientation as the other connectors on the cable.
(7) The front panel switch board could then be connected to either of the relay boards (no need to connect it to both).

## Swimming Pool Water Level Control

I want a sensor to determine the level of water in a swimming pool and I also want to feed the information to the Velleman USB experimental interface board.

I think it could come in analog format from the sensor, based on pressure, or maybe in digital format based on which wire is wet. I want to use the information to control "top-ups", both from mains and from stormwater diversion.

The distance from the "start filling" to the "stop filling from mains" would be about 20mm and the range to the "absolutely stop filling from stormwater" would be about 50mm.

That leads to the question of accuracy. Analog would be best in terms of flexibility but would this difference in pressure be to too small?

On the other hand, could I just connect a couple of 2-wire pairs direct to the Velleman and detect when they got wet? (H. R., via email).

● We have published several water tank level meters based on contact with water which provide a voltage proportional to water depth and another based on a pressure sensor.

These designs were published in the April 2002 and July 2007 issues of SILICON CHIP (both based on water contacts) and in November 2007, the latter using a pressure sensor which gives a voltage proportional to water pressure.

The pressure sensor based meter provides an accurate voltage against level (or water height) while the contact sensor would require the contacts to be placed at the water levels required.

Alternatively, a float switch could be used in the upper and lower water level positions in a waterproof box at the side of the pool (or through the side in an-above ground pool). A suitable float switch is available from Jaycar (Cat. SF0920).

even if the power went off or it was switched off at the wall.

It just shows how well a stereo system can withstand certain conditions, although if the stereo has been switched off for quite some time the stations need to be reprogrammed. Is the reason that a stereo retains its stations after being switched off at the wall because there is an internal battery installed? (K. C., Wangaratta, Vic).

● There are two ways in which video or audio equipment can retain station settings etc when power is not available. The first is with the aid of a backup battery or super-capacitor to maintain a section of RAM. The other method involves storing the data in non-volatile memory – which does not need power to retain data.

It's possible that your Akai stereo has an internal backup battery which has failed. If so, it should be replaced.

## Questions on ultrasonic anti-fouling unit

I have a 37-foot fibreglass yacht fitted with a Barnikil unit driving four transducers The drive unit burnt out and I have been unable to source a replacement from the original Canadian company. The transducers look like the back-drive unit of a speaker epoxied to the hull.

Is it possible for your Ultrasonic Anti-Fouling Unit (September & November 2010) to drive them?

Secondly, I also have an 11.5-metre boat. Can I use two transducers and one driver unit, using a 60-minute timer to switch from one to the other? This could use a 555 chip with a DPDT relay to alternate the transducers or a 556 to momentarily cut power, whilst alternating the transducer, if the momentary break of the switch could damage the driver.

This would save the price of a new driver and stops any problems using multiple driver/transducers units that may possibly interfere with each other. (D. H., Vale Park, SA).

● Our Ultrasonic Anti-Fouling Unit is only suitable for driving piezoelectric transducers. It will not drive transducers with "voice coils".

However, while transducers similar to loudspeaker drivers were used in early ultrasonic anti-fouling systems such as those used on naval ships, we would be surprised if they have been used in recent years because they require far more power to drive than piezo transducers.

One way to find out would be to measure the transducers themselves. If they have a low resistance, ie, anything under 100Ω, then they are coil transducers. But it is more likely that you will find that they are piezoelectric and this will be confirmed if they have substantial capacitance and very high resistance. For comparison, the transducers employed in our ultrasonic system (and equivalent commercial units which are very similar) have a capacitance of between 3000pF and 4000pF (3nF to 4nF) and very high resistance of many megohms.

If your transducers fall into this capacitance range, then there is a fair chance that they can be satisfactorily driven by our control unit. However, you would need one control unit for each transducer.

Your suggestion of using a relay to switch between two transducers is a great idea. There would be no need to cut the power to the circuit while switching the transducers but you would need to use a DPDT relay with 250VAC contacts.

## Multi-channel anti-fouling

I have a number of questions regarding the article on Ultrasonic Anti-Fouling Unit For Boats, (SILICON CHIP, September & November 2010). I would like to use this design as a basis for a dual-channel or triple-channel unit, as it seems wasteful to duplicate many of the parts.

I have inspected the source code and have come to the conclusion that the frequencies used within each band were chosen as a programming convenience, rather than for any specific need to incorporate them in the design. This is not a criticism but I would be interested if there was another reason. Furthermore, the overall range of frequencies seems limited compared with some commercial units. Is this due to the properties of the transducer?

From the description and the source code, I note that there is a 500ms no-signal gap between each burst. Is this gap to conserve power, to allow the transducer to cool, or for another reason? In my multi-channel unit I could,

# *Is your hip-pocket nerve hurting?*

***We know how you feel – prices seem to be going up all the time.***

***But you can save money by taking out a SILICON CHIP subscription.***

***A 12-month subscription will get you 12 issues for the price of less than 11!***

***For an even bigger discount, a 2-year subscription gets you 24 issues for the price of 20!***

***Best of all, a 2-year subscription gives you longer protection against future price rises.***

***Count the advantages:***

1. It's cheaper – you $ave money!
2. It's delivered right to your mail box!!
3. You can always be sure you'll receive it!!!
4. We pick up all the postage and handling charges!!!!
5. You will never miss an issue because it's sold out (or you forgot)!!!!!

## *PLACE YOUR ORDER NOW AND START $AVING!*

Please tick box required

- ❑ **6 MONTHS *SILICON CHIP*** ($52.00)
- ❑ **12 MONTHS *SILICON CHIP*** ($97.50) ..... ❑ **OR WITH BINDER** ($115.00)
- ❑ **24 MONTHS *SILICON CHIP*: ($188.00)** ..... ❑ **WITH 2 BINDERS** ($222.00)

**Your Name**_____ **Address**_____

_____ **Postcode**_____ **Daytime Phone No. (** **)**_____ **Email address** _____

**Method of Payment:** ❑ EFT (ring or email for details) ❑ Cheque/Money Order ❑ PayPal ❑ Visa Card ❑ Master Card

Card No..... Card expiry date: .....

Signature_____

| To Place Your Order: | eMAIL (24/7) | OR | FAX (24/7) | OR | PAYPAL (24/7) | OR | PHONE - (9-5, Mon-Fri) | OR | SNAIL MAIL |
|---|---|---|---|---|---|---|---|---|---|
| | silicon@siliconchip.com.au with order & credit card details | | This form (or a photocopy) to (02) 9939 2648 with all details | | Use PayPal to pay silicon@siliconchip.com.au | | Call (02) 9939 3295 with your credit card details | | This form to PO Box 139, Collaroy, NSW 2097 |

*These prices and comparisons refer to Australian subscriptions. Other countries are subject to exchange rates – please see page 98 of this issue.

if necessary, alternate the drive to the transducers but this would require a different PIC microcontroller.

It strikes me that an improvement in the design would be to pot the transformer with (or nearby) the transducer, splitting the unit into a control unit and a driver unit. This would eliminate the need to use high quality OFC loudspeaker flex as supplied by Jaycar to the transducer (a major cost) as well as reducing voltage loss. This also has the advantage of keeping all the high voltages within a contained area.

In this scenario, I envisage that the Mosfets would also be included in the driver unit or perhaps with a second pair of Mosfets as line-drivers within the control unit. I would appreciate your comments on this approach.

While on the subject of the Mosfets, what is the purpose of the 10Ω resistors between the PIC outputs and the gates? Is there any reason why each PIC output could not drive two (or three) Mosfets for a multi-channel unit? This depends on your answer to my second question, above.

The transformer has me somewhat bewildered. I have not had any experience of transformer winding, so I'm perplexed as to why the primary is wound using figure-8 flex, rather than side-by-side windings in enamelled copper wire. I am also having difficulty in sourcing 3C85 cores. Are these critical? Have you ever published a "Winding Transformers Guide"?

The PSU section of the unit specifies low-ESR capacitors. These are very expensive, so are they strictly necessary in a PSU? Also the 2200μF capacitor is specified as 25V and the 100μF capacitors as 16V. Would 16V and 10V, respectively, not suffice? (N. M., via email).

● The range of frequencies that drive the ultrasonic transducer are those necessary to prevent algal growth. In fact, the PIC programming had to comply with the requirement to cover this frequency range with small steps in frequency as the range is covered; it was not a matter of programming convenience. The transducer operates up to 40kHz with most power being produced at or around its 40kHz resonance.

The 500ms (nominal) no-signal period can be used to drive a second set of transducers. This gap period in driving the transducer is in keeping with commercial ultrasonic anti-fouling units and allows for bursts of ultrasonic energy rather than a continuous signal.

You cannot remove the transformer from the driver and place it near the transducer. The transformer needs to be located near the primary winding driver circuitry. Long leads to the transformer will reduce the efficiency of the transformer with much of the primary winding being outside the core. It is not necessary to use OFC leads but the insulation needs to be 250VAC-rated.

The 10Ω resistors are included to prevent parasitic oscillation each time the Mosfets switch on or off.

It is best to use separate PIC outputs to drive each Mosfet. The switch-on voltage differs between individual Mosfets and especially when driving a different transformer when oscillation can occur if another Mosfet is driven from the same PIC output.

Figure-8 wire is used for a number of reasons. First, it fully fills the transformer bobbin so that the transformer is fully utilised. Second, it provides good insulation between the primary and secondary, whereas winding wire would require a insulating barrier between primary and secondary. Winding wire is also too fine to fully utilise the core volume.

Finally, the figure-8 cable automatically provides for an easy way to do bifilar winding, with each wire marked (one with a striped side) for easy termination identification. The transformer core material is not critical, provided it can operate down to 20kHz.

Low-ESR capacitors are specified because the power supply is required to deliver high peak currents at frequencies between 20kHz and 40kHz. The 2200μF capacitor voltage rating is higher than usual because the higher voltage rated capacitors have a higher ripple current rating which this design required.

Standard capacitors would be likely to fail within a short period.

## Running A 60Hz Ferro-Resonant Transformer At 50Hz

I have a battery charger integrated into my imported American boat that is not providing a charge. The unit uses a ferro-resonant transformer having a primary input at 115VAC, a secondary which should deliver 14.2V and a tank coil with a capacitor across it. The capacitor is labelled "6MF 660 AC 60Hz".

The tank coil circuit was designed for 60Hz mains. Since we have 50Hz in Australia, I need to retune the resonance of the tank coil. Should I reduce the value of the capacitor by 20% since we have a 20% reduction in cycles? Say to 4.8μF? (C. X, Bribie Island, Qld).

● The resonance at 60Hz is 6μF in parallel with 1.17H ($F = 1/(2\pi\sqrt{LC})$).

For 50Hz, a 1.17H coil resonates with an 8.6μF capacitor. Therefore you will need to increase the capacitance by connecting a 2.6μF capacitor (or a value close to that) in parallel with the existing 6μF unit.

However, there are still two issues to address. First, for shore power, we assume you are using a 230V:110V step-down transformer to feed the 110V ferro-resonant charger – that may or may not cause problems.

Second, we assume you have a diesel generator when you are away from shore power but that will presumably run at 110V and 60Hz which means that you still need the original charger configuration available in that circumstance.

## Replacement speed control for a treadmill

I have a treadmill which has blown the speed controller board. The DC motor, which is rated at 160V and 6A, is still functional and was powered directly from rectified mains 240VAC via PWM.

Based on theory and what is left to measure, the gate voltage was approx 20V, supplied by a bridge rectified mains transformer. Will the Upgraded Speed Controller (Silicon Chip, June 2011) drive this motor with the following modifications? – (1) replace the voltage regulator with a BA7820CP and power the board with 26V DC; (2) Replace the IRF1405 Mosfets with IRFP450, ZD1 and ZD2 with 24V 1W 1N4491, and D1 MBR20100CT with a FEP30JP. The IRFP450s and the FEP30JP are the original parts used on the defunct board.

I intend to make a sub-board to

# SILICON CHIP

siliconchip.com.au

## YOUR DETAILS

## NEED PCBs?

**You can get the latest PCBs and micros direct from SILICON CHIP!**

**See p100 for full details . . .**

## Order Form/Tax Invoice

Silicon Chip Publications Pty Ltd
ABN 49 003 205 490
PO BOX 139, COLLAROY NSW 2097
email: silicon@siliconchip.com.au
Phone (02) 9939 3295 Fax (02) 9939 2648

This form may be photocopied without infringing copyright.

**Your Name**_____ (PLEASE PRINT)

**Address**_____

**Postcode**_____ **Daytime Phone No. (** **)**_____ **Email address** _____

**Method of Payment:** ❑ EFT (ring or email for details) ❑ Cheque/Money Order ❑ PayPal ❑ Visa Card ❑ Master Card

Card No. | | | | | | | | | | | | | | | | Card expiry date: | | | | |

Signature_____

**YOUR ORDER SILICON CHIP PRINTED EDITION SUBSCRIBERS# QUALIFY FOR 10% DISCOUNT (except on subscriptions!)**
**SIMPLY TICK THE ITEMS REQUIRED – DON'T FORGET TO FILL IN DETAILS ABOVE. WE'LL WORK THE TOTAL OUT FOR YOU AND SEND YOU A RECEIPT WITH YOUR ORDER**

### SILICON CHIP SUBSCRIPTIONS (all prices include P&P)

- ❑ AUSTRALIA 6 MONTHS (INC. GST) ..... $52.00
- ❑ AUSTRALIA 12 MONTHS (INC. GST) ..... $97.50
- ❑ AUSTRALIA 12 MONTHS WITH BINDER (INC. GST) ..... $115.00
- ❑ AUSTRALIA 24 MONTHS (INC. GST) ..... $188.00
- ❑ AUSTRALIA 24 MONTHS WITH 2 BINDERS (INC. GST) ..... $222.00
- ❑ NEW ZEALAND 6 MONTHS (AIR MAIL) ..... $AU55.00
- ❑ NEW ZEALAND 12 MONTHS (AIR MAIL) ..... $AU99.00
- ❑ NEW ZEALAND 24 MONTHS (AIR MAIL) ..... $AU196.00
- ❑ OVERSEAS (EXCEPT NZ) 6 MONTHS (AIR MAIL) ..... $AU80.00
- ❑ OVERSEAS (EXCEPT NZ) 12 MONTHS (AIR MAIL) ..... $AU140.00
- ❑ OVERSEAS (EXCEPT NZ) 24 MONTHS (AIR MAIL) ..... $AU265.00

**NEW! CONVENIENT AUTOMATIC SUBSCRIPTION RENEWAL:**

❑ Tick here if you'd like us to automatically renew your subscription when it elapses (ie, 6 month, 12 month or 24 month). We'll renew until you tell us to stop!

### SILICON CHIP BACK ISSUES/ARTICLE PHOTOCOPIES

❑ **SILICON CHIP BACK ISSUES*; SC/EA/ETI PHOTOCOPIES**
– includes P&P – $12.00 within Australia; $15.00 overseas

*where in stock - photocopy of article supplied where issue is out of stock. EA/ETI: no back issues left, only photocopies available. Price is for each back issue or each article photocopy.

Nominate issue and article required: Month:..... Year:.....

Article required:.....

Please attach list if more than one back issue or photocopy required. There is a 10% discount for ten or more back issues and/or photocopies (no further discount applies).

### SILICON CHIP MAGAZINE BINDERS

❑ **Embossed "SILICON CHIP", securely holds 12 months+ of issues**
Available in Australia only ..... $14.95

### PCBs, PANELS, PROGRAMMED MICROS

**Many PCBs and panels, along with some pre-programmed microprocessors and microcontrollers are now available direct from SILICON CHIP.**
See the separate page listing those currently available on page 100.

### SILICON CHIP BOOKSHOP (P&P additional – See below)

❑ PERFORM. ELECT. FOR CARS **PLUS** ELECTRONIC PROJECTS FOR CARS (2003) – last few, some may be shop-soiled, – **BOTH** BOOKS ... ~~$21.95~~ now only $15.00

- ❑ AC MACHINES ..... $66.00
- ❑ AMATEUR SCIENTIST CD NEWEST Version 4.0 ..... $62.00
- ❑ AUDIO POWER AMPLIFIER DESIGN – SELF ..... $81.00
- ❑ BUILD YOUR OWN ELECTRIC MOTORCYCLE ..... $40.00
- ❑ DVD PLAYERS AND DRIVES ..... $71.00
- ❑ ELECTRIC MOTORS AND DRIVES ..... $51.00
- ❑ NEWNES GUIDE TV & VIDEO TECHNOLOGY ..... $49.00
- ❑ OP AMPS FOR EVERYONE ..... $100. 00
- ❑ PIC IN PRACTICE ..... $60.00
- ❑ PIC MICROCONTROLLERS - KNOW IT ALL ..... $83.00
- ❑ PIC MICROCONTROLLER - PERSONAL INTRO COURSE ..... $60.00
- ❑ PRACT. GUIDE TO SATELLITE TV (7th edition) ..... $49.00
- ❑ PRACTICAL RF HANDBOOK ..... $61.00
- ❑ PRACT. VAR. SPEED DRIVES/POWER ELECT ..... $73.00
- ❑ PROG. 32-BIT MICROCONTROLLERS IN C ..... $79.00
- ❑ PROGRAMMING AND CUSTOMIZING THE PICAXE ..... $65.00
- ❑ RADIO, TV AND HOBBIES ON DVD-ROM ..... $62.00
- ❑ RF CIRCUIT DESIGN ..... $63.00
- ❑ SELF ON AUDIO (2nd edition) ..... $69.00
- ❑ SMALL SIGNAL AUDIO DESIGN ..... $88.00
- ❑ SWITCH, POWER SUPPLIES A-Z (inc CD-ROM) ..... $91.00
- ❑ TV ACROSS AUSTRALIA ..... ***SUPER SPECIAL – LAST FEW!*** ~~$34.95~~ ..... $29.95
- ❑ USING UBUNTU LINUX ..... $27.00

***#10% discount offer does not apply to online edition subscribers nor to website orders***

**P&P RATES:**
Subscriptions, back issues and project manuals: **P&P included**
Binders if available Australia only: **$10.00 per order; for 5 or more P&P is free**
Books: **Aust. $10 per order; NZ: $AU12 per book; Elsewhere $AU18 per book**

**To Place Your Order:**

**eMAIL (24/7)** silicon@siliconchip.com.au with order & credit card details **OR**

**FAX (24/7)** This form (or a photocopy) to (02) 9939 2648 with all details **OR**

**PAYPAL (24/7)** Use PayPal to pay silicon@siliconchip.com.au **OR**

**PHONE - (9-5, Mon-Fri)** Call (02) 9939 3295 with your credit card details **OR**

**MAIL** This form to PO Box 139, Collaroy NSW 2097

*ALL ITEMS SUBJECT TO AVAILABILITY. PRICES VALID FOR MONTH OF MAGAZINE ISSUE ONLY. ALL PRICES IN AUSTRALIAN DOLLARS AND INCLUDE GST WHERE APPLICABLE.

## How To Charge Smart Phones In A Car

I have a Samsung smart phone which has a Micro USB connection. I find that I can charge the phone using the charger that came with the unit or by plugging it into a USB port on a computer.

What I have not been able to do is get a 12V USB plug to work. I have tried several from different companies and none of them trigger the phone into the "charging mode". Chatting with one of the staff members of an electronics company, he suggested that this is not an uncommon problem.

The question is then, is there a 12V (cigarette lighter type) "smart plug" around that can cause the phone to start charging while in the car? If not, could one of your very clever design people come up with something that we can use in our cars to charge these "smart" devices? (G. H., via email).

● Some devices that can charge from USB will draw current as soon as they sense 5V from the host PC/charger. Others require software communications before they begin drawing current or else require a special cable or charger which signals to them that they can draw current.

Technically, devices should not draw more than 100mA from the bus until they have negotiated it with the computer, as the USB power source can be shared between multiple ports and if they did, they risk a bus reset which would affect other connected devices.

Therefore, these devices are supposed to communicate with the PC and ask for the power before consuming it. With a dedicated USB charger (whether it's mains-powered or running from 12V DC) there isn't usually a host PC to communicate with and ask for power.

The USB3 standard now provides a common method for detecting this condition (the D+ and D- pins are connected directly together by the charger) but before that, there was no standard on how a device can detect that it is plugged into a USB charger and so can draw current without asking.

Some manufacturers use a special cable which connects the fifth pin on a USB Mini connector to ground via a resistor. Some use biasing voltages on the D+ and/or D- pins.

We haven't been able to find information on what a Samsung smart phone requires before it will draw current but it is likely to be one of these things. If you can't figure out what the signal is, you basically have four options:

(1) Buy a charger from Samsung designed for your phone, which will use the appropriate signalling method;

(2) Buy a generic charger that advertises it will work with your phone or get one that works with a wide variety of phones and take a punt;

(3) Get a special cable designed for charging your phone and connect the phone to your existing charger with it;

(4) Experiment with the various common signalling methods until you find one which works with your phone.

accommodate these parts and other original 240VAC components and connect the two with flying leads. The original had the Mosfets on the "hot side" (positive) of the motor circuit. Would you recommend changing this to the "low side"?

Given the motor specifications, it is obvious it will be necessary to limit the duty cycle. It also means there will be no flashing LEDs and counts but it is my experience that these have little effect on one's BMI (body mass index). (N. C., Mahogany Creek, WA).

● You should be able to run the motor controller from 26V DC and just change the Mosfets and diode that were from the original PWM controller. The zener diodes should be kept at less than 20V because the Mosfet gate voltages should not exceed ±20V.

You would need to use the Mosfet low side drive for the motor. The diode (D1) would connect to the mains DC supply rather than the 26V.

## Measuring transformers for valve circuits

Has Silicon Chip produced a project for a digital impedance meter to check and match output transformer impedances to different output valves? Of course, I could do it by measurements but it would be easier with a meter. (E. M., via email).

● We have not produced a suitable design and in any case it is not that easy to test transformer impedances, as such.

The impedance (or load) presented by an audio output transformer is the product of the speaker load impedance multiplied by the square of the turns ratio. So if you had a speaker load impedance of 8Ω and you connected it to a transformer with a step-down ratio (same as turns ratio) of 30:1, the calculated load impedance presented by the transformer's primary would then be 7.2kΩ.

If you have an unknown transformer, you first need to work out its step-down ratio by applying an AC voltage (at say, 1kHz) to its primary winding and then measuring the resultant voltage at the secondary. Alternatively, you could do it the other way around, ie, by applying a test voltage to the secondary winding and then measuring the resultant voltage across the primary.

## Building the USB Recording Interface

I would like to build the USB Recording Interface (Silicon Chip, June 2011) but I don't know where to buy the parts and I have never built anything electronic before although I consider myself handy. Also, I am not sure what tools I would need for this project. (G. P., via email).

● You can get the PCB direct from Silicon Chip and the following parts from Element14 (**www.element14.com**): 12MHz HC-49 crystal (order code 7940142); MCP6024-I/P (order code 1627199 or get them from Microchip Direct [**www.microchipdirect.com**]); PCM2902 (order code 8434700); REG103GA-A (order code 1207256); 1nF NP0 ceramic capacitors (order code 1457666) (or you could use 1nF MKTs or greencaps which should work just as well and are available from Altronics & Jaycar); 820pF NP0 ceramic capacitors (order code 1694329).

The rest of the parts should be read-

# PCBs for SILICON CHIP projects

Looking for a PCB to build that latest and greatest *SILICON CHIP* project? You can order the most recent projects' PCBs direct from *SILICON CHIP*. Beautifully made, very high quality fibreglass boards with pre-tinned tracks, silk screen overlays and where applicable, solder masks.

Best of all, those boards with fancy cut-outs or edges are already cut out to the *SILICON CHIP* specifications – no messy blade work required!

- **These boards are IN STOCK and ready for despatch.**
- **Even if stock runs out (eg, for high demand), in most cases there will be no longer than a two-week wait.**
- **One low p&p charge: $10 per order, regardless of how many boards you order! (Australia only; overseas clients – email us for a postage quote).**
- **New project boards will normally be available within days of the magazine on-sale date: no waiting!**

| PROJECT | PUBLISHED | CODE | Price* |
|---|---|---|---|
| CHAMP: SINGLE CHIP AUDIO AMPLIFIER | FEB 1994 | 01102941 | $5.00 |
| PRECHAMP: 2-TRANSISTOR PREAMPLIFIER | JUL 1994 | 01107941 | $5.00 |
| HEAT CONTROLLER | JULY 1998 | 10307981 | $25.00 |
| SMART SLAVE FLASH TRIGGER | JUL 2003 | 13107031 | $10.00 |
| 12AX7 VALVE AUDIO PREAMPLIFIER | NOV 2003 | 01111031 | $25.00 |
| POOR MAN'S METAL LOCATOR | MAY 2004 | 04105041 | $10.00 |
| BALANCED MICROPHONE PREAMP | AUG 2004 | 01108041 | $25.00 |
| POCKET TENS UNIT | JAN 2006 | 11101061 | $25.00 |
| STUDIO SERIES RC MODULE | APRIL 2006 | 01104061 | $25.00 |
| ULTRASONIC EAVESDROPPER | AUG 2006 | 01208061 | $25.00 |
| RIAA PREAMPLIFIER | AUG 2006 | 01108061 | $25.00 |
| GPS FREQUENCY REFERENCE (A) (IMPROVED) | MAR 2007 | 04103073 | $55.00 |
| GPS FREQUENCY REFERENCE DISPLAY (B) | MAR 2007 | 04103072 | $30.00 |
| KNOCK DETECTOR | JUNE 2007 | 05106071 | $25.00 |
| SPEAKER PROTECTION AND MUTING MODULE | JULY 2007 | 01207071 | $25.00 |
| CDI MODULE SMALL PETROL MOTORS | MAY 2008 | 05105081 | $15.00 |
| LED/LAMP FLASHER | SEP 2008 | 11009081 | $10.00 |
| USB-SENSING MAINS POWER SWITCH | JAN 2009 | 10101091 | $45.00 |
| DIGITAL AUDIO MILLIVOLTMETER | MAR 2009 | 04103091 | $35.00 |
| INTELLIGENT REMOTE-CONTROLLED DIMMER | APR 2009 | 10104091 | $10.00 |
| INPUT ATTENUATOR FOR DIG. AUDIO M'VOLTMETER | MAY 2009 | 04205091 | $10.00 |
| 6-DIGIT GPS CLOCK | MAY 2009 | 04105091 | $35.00 |
| 6-DIGIT GPS CLOCK DRIVER | JUNE 2009 | 07106091 | $25.00 |
| 6-DIGIT GPS CLOCK AUTODIM ADD-ON | SEPT 2009 | 04208091 | $10.00 |
| STEREO DAC BALANCED OUTPUT BOARD | JAN 2010 | 01101101 | $25.00 |
| DIGITAL INSULATION METER | JUN 2010 | 04106101 | $25.00 |
| ELECTROLYTIC CAPACITOR REFORMER | AUG 2010 | 04108101 | $55.00 |
| ULTRASONIC ANTI-FOULING FOR BOATS | SEP 2010 | 04109101 | $25.00 |
| HEARING LOOP RECEIVER | SEP 2010 | 01209101 | $25.00 |
| TOSLINK TO S/PDIF/COAX CONVERTER | OCT 2010 | 01210102 | $10.00 |
| DIGITAL LIGHTING CONTROLLER SLAVE UNIT | OCT 2010 | 16110102 | $45.00 |
| HEARING LOOP TESTER/LEVEL METER | NOV 2010 | 01111101 | $25.00 |
| UNIVERSAL USB DATA LOGGER | DEC 2010 | 04112101 | $25.00 |
| HOT WIRE CUTTER CONTROLLER | DEC 2010 | 18112101 | $25.00 |
| 433MHZ SNIFFER | JAN 2011 | 06101111 | $10.00 |
| CRANIAL ELECTRICAL STIMULATION | JAN 2011 | 99101111 | $30.00 |
| HEARING LOOP SIGNAL CONDITIONER | JAN 2011 | 01101111 | $30.00 |
| LED DAZZLER | FEB 2011 | 16102111 | $25.00 |
| 12/24V 3-STAGE MPPT SOLAR CHARGER | FEB 2011 | 14102111 | $25.00 |
| SIMPLE CHEAP 433MHZ LOCATOR | FEB 2011 | 06102111 | $5.00 |
| THE MAXIMITE | MAR 2011 | 06103111 | $25.00 |

| PROJECT | PUBLISHED | CODE | Price* |
|---|---|---|---|
| UNIVERSAL VOLTAGE REGULATOR | MAR 2011 | 18103111 | $15.00 |
| 12V 20-120W SOLAR PANEL SIMULATOR | MAR 2011 | 04103111 | $25.00 |
| MICROPHONE NECK LOOP COUPLER | MAR 2011 | 01209101 | $25.00 |
| PORTABLE STEREO HEADPHONE AMP | APRIL 2011 | 01104111 | $25.00 |
| CHEAP 100V SPEAKER/LINE CHECKER | APRIL 2011 | 04104111 | $25.00 |
| PROJECTOR SPEED CONTROLLER | APRIL 2011 | 13104111 | $10.00 |
| SPORTSYNC AUDIO DELAY | MAY 2011 | 01105111 | $30.00 |
| 100W DC-DC CONVERTER | MAY 2011 | 11105111 | $25.00 |
| PHONE LINE POLARITY CHECKER | MAY 2011 | 12105111 | $10.00 |
| 20A 12/24V DC MOTOR SPEED CONTROLLER MK2 | JUNE 2011 | 11106111 | $25.00 |
| USB STEREO RECORD/PLAYBACK | JUNE 2011 | 07106111 | $25.00 |
| VERSATIMER/SWITCH | JUNE 2011 | 19106111 | $25.00 |
| USB BREAKOUT BOX | JUNE 2011 | 04106111 | $10.00 |
| ULTRA-LD MK3 200W AMP MODULE | JULY 2011 | 01107111 | $25.00 |
| PORTABLE LIGHTNING DETECTOR | JULY 2011 | 04107111 | $25.00 |
| RUDDER INDICATOR FOR POWER BOATS (4 PCBs) | JULY 2011 | 20107111-4 | $80 per set |
| VOX | JULY 2011 | 01207111 | $25.00 |
| ELECTRONIC STETHOSCOPE | AUG 2011 | 01108111 | $25.00 |
| DIGITAL SPIRIT LEVEL/INCLINOMETER | AUG 2011 | 04108111 | $15.00 |
| ULTRASONIC WATER TANK METER | SEP 2011 | 04109111 | $25.00 |
| ULTRA-LD MK2 AMPLIFIER UPGRADE | SEP 2011 | 01209111 | $5.00 |
| ULTRA-LD MK3 AMPLIFIER POWER SUPPLY | SEP 2011 | 01109111 | $25.00 |
| HIFI STEREO HEADPHONE AMPLIFIER | SEP 2011 | 01309111 | $45.00 |
| GPS FREQUENCY REFERENCE (IMPROVED) | SEP 2011 | 04103073 | $55.00 |
| DIGITAL LIGHTING CONTROLLER LED SLAVE | OCT 2011 | 16110111 | $30.00 |
| QUIZZICAL QUIZ GAME | OCT 2011 | 08110111 | $25.00 |
| ULTRA-LD MK3 PREAMP & REMOTE VOL CONTROL | NOV 2011 | 01111111 | $35.00 |
| ULTRA-LD MK3 INPUT SWITCHING MODUL | NOV 2011 | 01111112 | $25.00 |
| ULTRA-LD MK3 SWITCH MODULE | NOV 2011 | 01111113 | $10.00 |
| ZENER DIODE TESTER | NOV 2011 | 04111111 | $25.00 |
| MINIMAXIMITE | NOV 2011 | 07111111 | $10.00 |
| ADJUSTABLE REGULATED POWER SUPPLY | DEC 2011 | 18112111 | $5.00 |
| DIGITAL AUDIO DELAY | DEC 2011 | 01212111 | $30.00 |
| DIGITAL AUDIO DELAY FRONT & REAR PANELS | DEC 2011 | 01212112/3 | $20 per set |
| AM RADIO | JAN 2012 | 06101121 | $10.00 |
| STEREO AUDIO COMPRESSOR | JAN 2012 | 01201121 | $30.00 |
| STEREO AUDIO COMPRESSOR FRONT & REAR PANELS | JAN 2012 | 01201121P1/2 | $20.00 |
| 3-INPUT AUDIO SELECTOR (SET OF 2 BOARDS) | JAN 2012 | 01101121/2 | $30 per set |
| CRYSTAL DAC | FEB 2012 | 01302121 | $20.00 |
| SWITCHING REGULATOR | FEB 2012 | 18102121 | $5.00 |
| (SEMTEST BOARDS WILL BE AVAILABLE IN MARCH 2012) | | | |

## AND NOW THE PRE-PROGRAMMED MICROS, TOO!

*Micros from copyrighted and contributed projects may not be available.*

As a service to readers, *SILICON CHIP* is now stocking microcontrollers and microprocessors *used in new projects* (from 2012 on) and some selected older projects – **pre-programmed and ready to fly! Price (any project, per micro) is just $15.00 each + $10 p&p per order**

| | |
|---|---|
| PIC18F2550-I/SP | Batt Capacity Meter (Jun09), Intelligent Fan Controller (Jul10) |
| PIC18F4550-I/P | GPS Car Computer (Jan10), GPS Boat Computer (Oct10) |
| PIC16F877A-I/P | 6-Digit GPS Clock (May-Jun09), Lab Digital PSU (Jul10) |
| dsPIC33FJ128GP802-I/SP | Digital Audio Signal Generator (Mar-May10), Digital Lighting Controller (Oct-Dec10), SportSync (May11), Digital Audio Delay (Dec11) |
| PIC16F88-E/P | Projector Speed (Apr11), Vox (Jun11), Ultrasonic Water Tank Level (Sep11), Quizzical (Oct11), Ultra-LD Preamp (Nov11) |
| PIC18F27J53-I/SP | USB Data Logger (Dec10-Feb11) |
| PIC32MX795F512H-80I/PT | Maximite (Mar11), miniMaximite (Nov11) |
| PIC18LF18K22 | Digital Spirit Level (Aug11), G-Force Meter (Nov11) |
| PIC18F14K50 | USB MIDIMate (Oct11) |
| ATTiny861 | VVA Thermometer/Thermostat (Mar10), Rudder Position Indicator (Jul11) |
| PIC12F675 | UHF Remote Switch (Jan09), Ultrasonic Cleaner (Aug10), Ultrasonic Anti-fouling (Sep10) |
| ATTiny2313 | Remote-Controlled Timer (Aug10) |
| ATMega48 | Stereo DAC (Sep-Nov09) |
| PIC18F1320-I/SO | Intelligent Dimmer (Apr09) |

**When ordering, be sure to nominate BOTH the micro required and the project for which it must be programmed. We cannot read your mind!**
***Note: P&P is extra ($10 per order). Prices listed include GST and are valid only for month of publication of this list; thereafter are subject to change without notice.** 02/12

**ORDER BY ✓ PHONE: (02 9939 3295, 9am-4pm Mon-Fri) ✓ FAX: (02 9939 2648, 24 hours/7 days) ✓ EMAIL: (pcbs@siliconchip.com.au, 24 hours/7 days)**

ily available from Jaycar or Altronics.

As for tools, you will likely need the following:

- a soldering iron (temperature controlled type recommended)
- solder (0.7mm diameter)
- flux paste
- desoldering braid
- side-cutters
- small pliers
- medium Phillips head screwdriver
- electric drill (a small drill press is even better)
- metric drill bits (3-12mm say)
- tapered reamer (stepped drill bit also useful)
- needle file set
- sharp hobby knife
- spray adhesive
- laminator for the label. There are other options (eg, printing onto a transparency)
- angle tweezers
- a lead-bending jig (eg, Jaycar TH1810).

The most important skill to have is soldering. It takes a little practice to make a good solder joint. If you do it incorrectly it could cause the device to malfunction, possibly not immediately.

The trickiest soldering is installing surface-mount IC3 but it's actually quite simple once you know how and we have published several articles on soldering surface-mount chips. It helps to have a good temperature-controlled soldering iron with a medium-sized or small tip and the tip should be kept clean.

## Running two train controllers on a layout

I am adding a second Railpower IV (Silicon Chip, September & October 2008) to my model railway layout and want to be able to transfer trains from an inner track to an outer track using two controllers. Once a train has been transferred, the inner and outer tracks can be electrically isolated by the position of the points.

This works fine with the one controller but I now want to have the option of operating to two tracks independently when required. My query is when changing from one controller to the other there will be a back feed briefly to the first controller. Will this cause damage to this controller? Both will be set to the same direction during this operation.

Incidentally, the Railpower IV is a really good unit and I am very pleased with it. (I. D., via email).

- You are effectively trying to run two controllers connected to the same track and this is very bad practice. There could be a direct short across the track as one transistor in one controller connects a track to 0V while another transistor in the second controller connects the same track to its 17V supply.

Even if the the controllers were set for the same nominal speed and direction, there would be a short condition because, even if they were delivering exactly the same pulse width to the track, the pulses would not be synchronised.

If you want to run more than one

*. . . continued on page 104*

## Projector Speed Controller Causes Picture Blanking

I built the Projector Speed Controller as featured in the April 2011 issue. The controller seems the work correctly, changing speed constantly between high and low. However, when playing a movie (Super 8 ) and recording with a Sony Handycam DVD camera (DCR-DVD201E), the picture blanks out completely at random periods.

Did you have this problem or is it the type of camera used? The projector has a 3-vane shutter. Is there anything that can be done to fix this problem? (G. S., via email).

- There are several possibilities why your camcorder blanks out. One is that the speed control is not correct for your projector. Are you running at 16-2/3rd frames per second or 25? Most projectors with a 3-vane shutter run at 16 2/3rds fps and 25 fps projectors have a 2-vane shutter.

If it is meant to be 25 fps for Super 8, then the 3-vane shutter will provide 16 2/3rds fps when controlled instead of 25fps due to the 3-vanes. The speed control would be required to lock at 75Hz instead to get a frame rate of 25Hz. If this is the problem, it will show up as a regular blanking of picture. If so, the software would have to be changed to suit. However, it appears from your email that the blanking is random.

Alternatively, the problem might be with automatic exposure. Try setting the camcorder to have manual exposure. That way the exposure will not shut down and blank when it sees a sudden increase in brightness.

**WARNING!**

Silicon Chip magazine regularly describes projects which employ a mains power supply or produce high voltage. All such projects should be considered dangerous or even lethal if not used safely.

Readers are warned that high voltage wiring should be carried out according to the instructions in the articles. When working on these projects use extreme care to ensure that you do not accidentally come into contact with mains AC voltages or high voltage DC. If you are not confident about working with projects employing mains voltages or other high voltages, you are advised not to attempt work on them. Silicon Chip Publications Pty Ltd disclaims any liability for damages should anyone be killed or injured while working on a project or circuit described in any issue of Silicon Chip magazine.

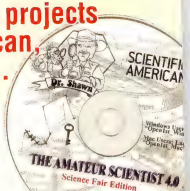
Devices or circuits described in Silicon Chip may be covered by patents. Silicon Chip disclaims any liability for the infringement of such patents by the manufacturing or selling of any such equipment. Silicon Chip also disclaims any liability for projects which are used in such a way as to infringe relevant government regulations and by-laws.

Advertisers are warned that they are responsible for the content of all advertisements and that they must conform to the Competition & Consumer Act 2010 or as subsequently amended and to any governmental regulations which are applicable.

FANTASTIC GIFT IDEA FOR STUDENTS OF ALL AGES!

# THE AMATEUR SCIENTIST

## An incredible CD with over 1000 classic projects from the pages of Scientific American, covering every field of science...




THE LATEST VERSION 4 - WITH EVEN MORE FEATURES!

Arguably THE most IMPORTANT collection of scientific projects ever put together! This is version 4, Super Science Fair Edition from the pages of Scientific American. As well as specific project material, the CDs contain hints and tips by experienced amateur scientists, details on building science apparatus, a large database of chemicals and so much more.

**ONLY $62.00**

**PLUS $10 Pack and Post within Australia**

NZ P&P: $AU12.00, Elsewhere: $AU18.00

*"A must for every science student, science teacher, science lab . . . or simply for those with an enquiring mind . . ."*

**Just a tiny selection of the incredible range of projects:**

- Build a seismograph to study earthquakes
- Make soap bubbles that last for months
- Monitor the health of local streams
- Preserve biological specimens
- Build a carbon dioxide laser
- Grow bacteria cultures safely at home
- Build a ripple tank to study wave phenomena
- Discover how plants grow in low gravity
- Do strange experiments with sound
- Use a hot wire to study the crystal structure of steel
- Extract and purify DNA in your kitchen
- Create a laser hologram
- Study variable stars like a pro
- Investigate vortexes in water
- Cultivate slime moulds
- Study the flight efficiency of soaring birds
- How to make an Electret
- Construct fluid lenses
- Raise butterflies as experimental animals
- Study the physics of spinning tops
- Build an apparatus for studying chaotic systems
- Detect metals i air, liquids, or solids
- Photograph an ant's brain and nervous system
- Use magnets to make fluids into solids
- Measure the metabolism of an insect . . .
- and many, many more (a thousand more, in fact!)

*See the V2 review in SILICON CHIP, October 2004. . . or read on line at siliconchip.com.au*

*This is the ALL-NEW Version 4 . . . it's even BETTER!*

## HERE'S HOW TO ORDER YOUR COPY:

BY PHONE:* (02) 9939 3295 9-5 Mon-Fri

BY FAX:# (02) 9939 2648 24 Hours 7 Days

BY EMAIL:# silicon@siliconchip.com.au 24 Hours 7 Days

BY PAYPAL:# silicon@siliconchip.com.au 24 Hours 7 Days

BY MAIL:# PO Box 139, Collaroy NSW 2097

BY INTERNET:^ siliconchip.com.a 24 Hours 7 Days

* Please have your credit card handy! # Don't forget to include your name, address, phone no and credit card details. ^ You will be prompted for required informati

**There's also a handy order form inside this issue.**

*Exclusive in Australia to:* **SILICON CHIP** siliconchip.com.au

# MARKET CENTRE

Cash in your surplus gear. Advertise it here in SILICON CHIP


**ELNEC IC PROGRAMMERS**

High quality
Realistic prices
Free software updates
Large range of adaptors
Windows 95/98/Me/NT/2k/XP

**CLEVERSCOPE USB OSCILLOSCOPES**

2 x 100MSa/s 10bit inputs + trigger
100MHz bandwidth
8 x digital inputs
4M samples/input
Sig-gen + spectrum analyser
Windows 98/Me/NT/2k/XP

**IMAGECRAFT C COMPILERS**

ANSI C compilers, Windows IDE
AVR, TMS430, ARM7/ARM9
68HC08, 68HC11, 68HC12

**GRANTRONICS PTY LTD**

www.grantronics.com.au



SPLat CONTROLS **Tough times demand innovative solutions!**

In tough economic times you need to watch every dollar. SPLat embedded controllers give OEMs more functionality per dollar than any competing product. Check out our website today and discover how we can help you remain competitive.

*Made in Australia, used by OEMs world-wide*

splat-sc.com



**Printed Circuit Board Manufacture**

48-Hour service • High quality • Low prices
1 offs to any quantity
Artwork design if required
*Call for obligation free quote...*
INSTANT PCBs, POBox 448, Avalon 2107
Ph (02)9974 1189 Fax (02)9974 5491

**Australian Valve Audio Transformers**

AVAT

Output Transformers
Power Transformers

WEB: WWW.AVAT.COM.AU
Ph: 03 94316863

**Issues Getting Dog-Eared?**

Keep your copies of SILICON CHIP safe with our handy binders

REAL VALUE AT $14.95 PLUS P&P

Available Aust. only. Price: $A14.95 plus $10 p&p per order (includes GST). Just fill in and mail the handy order form in this issue; or fax (02) 9939 2648; or call (02) 9939 3295 and quote your credit card number.

Buy five and get them postage free!



**Battery Packs & Chargers**

Siomar Battery Engineering
www.batterybook.com
Phone (08) 9302 5444


## FOR SALE

**LEDs! Nichia, Cree** and other brand name LEDs at excellent prices. LED drivers, including ultra-reliable linear driver options. Many other interesting and hard-to-find electronic items! **www.ledsales.com.au**

**PCBs & Micros:** Silicon Chip Publications can supply PCBs and programmed micros for recent (and some not so recent) projects described in the magazine. See our advert in this issue for further details. Phone (02) 9939 3295 or email **silicon@siliconchip.com.au**

**questronix.com.au** – audiovisual experts solve home, corporate security and devotional installation & editing woes. QuestAV CYP, Kramer TVone (02) 4343 1970 or **sales@questronix.com.au**

**PCBs MADE, ONE OR MANY.** Any format, hobbyists welcome. Sesame Electronics Phone (02) 8068 2713. **sesame@sesame.com.au** **www.sesame.com.au**

**MAXIMITE BREAKOUT BOARD:** 10 channels, 2 relays per board. 2 boards can be cascaded to get all 20 channels. Each channel can be configured as Digital In, Digital Out or Analog In, screw terminals. More information **www.hamfield.com.au**

## WANTED

**CUSTOMERS WANTED:** Truscotts Electronic World – large range of semiconductors and passive components for industry, hobbyist and amateur projects including Drew Diamond. 27 The Mall, South Croydon, Melbourne. Phone (03) 9723 3860. **www.electronicworld.com.au**

## KIT ASSEMBLY & REPAIR

**KEITH RIPPON KIT ASSEMBLY & REPAIR:**

* Australia & New Zealand;
* Small production runs.

Phone Keith 0409 662 794. **keith.rippon@gmail.com**

**GEOFF COPPA KIT ASSEMBLY AND TROUBLE SHOOTING SERVICE.** Phone Geoff on 0414226102. **coppamitchell2@bigpond.com**

### ADVERTISING IN MARKET CENTRE

**Classified Ad Rates:** $29.50 (incl. GST) for up to 20 words plus 85 cents for each additional word. Display ads: $54.50 (incl. GST) per column centimetre (max. 10cm). Closing date: 5 weeks prior to month of sale. To book, email the text to **silicon@siliconchip.com.au** and include your name, address & credit card details, or fax (02) 9939 2648, or phone (02) 9939 3295.

*www.siliconchip.com.au*

**RFMA** RF Modules Australia
Low Power Wireless Connectivity Specialists

**USB BLUETOOTH**
**PARANI UD100-G01**
Class 1 Bluetooth 2.0+EDR
Working distance to 300m
Toshiba or BlueSoleil driver
Optional 5dBi Dipole Antenna

**Applications:**
Rural
Utilities
Industrial
Commercial
Government
Meter Reading

**CONNECT TO YOUR SOLAR INVERTER THE EASY WAY!**

**RF Modules Australia**. P.O. Box 1957 Launceston, TAS., 7250.
Ph: 03-6331-6789. Email: sales@rfmodules.com.au. Web: rfmodules.com.au

**microbee** tm
**Australias own computer**

After almost 20 years, Microbee is back with a mixture of retro and new technology. Check out all of the details at our new website:

www.microbeetechnology.com.au

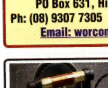
**Circuit Ideas Wanted**

We pay up to $60 for contributions to Circuit Notebook, or you could win aan LCR meter.

*Silicon Chip Publications, PO Box 139, Collaroy, NSW 2097.*

**DOWNLOAD OUR CATALOG AT**
**www.iinet.net.au/~worcom**

**WORLDWIDE ELECTRONIC COMPONENTS**
**PO Box 631, Hillarys, WA 6923**
**Ph: (08) 9307 7305 Fax: (08) 9307 7309**
**Email: worcom@iinet.net.au**



For this kit and **hundreds** more like it, shop on-line at: ***www.kitstop.com.au*** electronics - the fun starts here

**FK708 AM Radio Kit**
**Ideal classroom project or just for fun.**
**Simple construction includes amplifier and speaker**
**Shelf and pocket cases available**
**Value!!! $15.27 inc GST Plus $6.45 P & P**

## Ask SILICON CHIP

*. . . continued from p101*

controller on your layout you really need to install block switching between the inner and outer loops, with double-pole changeover relays. You cannot use any system where the two controller outputs are effectively connected in parallel, even if it occurs only briefly.

## Modifying the Sunset Switch

In June 2003 you published a design for a Sunset Switch. This includes a timer which I don't need and which adds to the cost and complexity of the circuit.

Has there been a design that has only the sunlight sensing with hysteresis? I need to turn some lights on overnight only. Perhaps the circuit could be adapted by taking the output at pin 7 of IC1 and running the relay through Q1 from there? Then there would be no need for Q2, IC2, IC3 etc? (J. B., via email).

● The Sunset Switch could be modified to remove the time-out as you suggest. There are several ways to do this. (1) One option is to remove IC2 and IC3, the DIP switch, S2 and S3, diodes D6-D11, transistor Q2 and the associated resistors and capacitors for the power-on reset, dawn light reset and for oscillator IC3. Pin 7 of IC1b then connects to the base of Q1 via the 3.9kΩ resistor.

That way, the relay would be closed whenever the sensor is in darkness. (2) To preserve the manual on and off switching, only remove IC3, the DIP switch and diodes D6-D9 plus the associated resistors and capacitors for IC3 at pins 9-11.

(3) Alternatively, the project can be built as shown and the DIP switches all left open so that there is no time-out.

Finally, the Solar-Powered Lighting Controller published in the May 2010 issue of SILICON CHIP can also be used as a sunset switch. SC

## Advertising Index

Altronics ..... 82-85
Amateur Scientist CD ..... 102
Australian Valve Audio ..... 103
Clarke & Severn Electronics ..... 91
Dyne Industries ..... 7
Emona Instruments ..... 7
Geoff Coppa ..... 103
Grantronics ..... 103
Harbuch Electronics ..... 12
Hare & Forbes ..... OBC
HK Wentworth ..... 10
Instant PCBs ..... 103
Jaycar ..... IFC,49-56
Keith Rippon ..... 103
Kitstop ..... 104
LED Sales ..... 103
LHP.NET.AU ..... IBC
Measurement Innovation ..... 91
Microbee Technology ..... 104
Microchip Technology ..... 41
Microzed Computers ..... 91
Mikroelectronika ..... 11
Mouser Electronics ..... 5
Ocean Controls ..... 3
Quest Electronics ..... 103
RKT Auctioneers ..... 89
RF Modules ..... 104
Sesame Electronics ..... 103
Silicon Chip Binders ..... 30,46,103
Silicon Chip Bookshop ..... 92-93
Silicon Chip Order Form ..... 98
Silicon Chip PCBs ..... 100,103
Silicon Chip Subscriptions ..... 96
Siomar Battery Engineering ..... 9,103
Splat Controls ..... 103
Truscotts Electronic World ..... 103
Wiltronics ..... 13
Wireless Design ..... 91
Worldwide Elect. Components ..... 104

# (02) 9620 9011
## LHP.NET.AU

**NON FOLDING**
20W : $59
50W : $150
80W : $250
100W : $300
120W : $350
200W : $599

**FOLDING**
60W : $199
80W : $299
100W : $350
120W : $399
160W : $499
200W : $599

FREE DELIVERY

**240VAC INFOMON PURE SINEWAVE SILENT INVERTER GENERATOR**
**2KVA: $499**
**3.5KVA: $799**

**LCD CHARGE CONTROLLER**
30A: $89
50A: $150

**FRIDGE FREEZER FREE BONUSES:** insulation cover, wall charger, & cigarette adaptor. **REDUCED!**
45L was $1499 NOW $499
80L was $1899 NOW $599

**INFOMON WIND TURBINE**
One of the most advanced wind turbines to generate some serious power, sold as a 1kW or 2kW complete kit with a stand and rectifier.
**LIMITED STOCK!**
1kW: $899 2kW: $1999

$49
**12V LED LIGHT STRIP**
5m, cut and reuse, weather proof, adhesive back, various colours!
**LED BAR LAMPS** available with a magnetic back! $49

was $1250
**NOW $499**

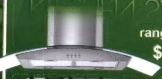
125CC

as $1450
OW $899

## TOOLS CLEARANCE

22CC HEDGE TRIMMER: $99
52CC CHAINSAW: $99
SELF PROPELLED LAWN MOWER: $250
PRESSURE WASHER: $199

## KITCHEN SALE



rangehood
**$199**

4 burner gas cooktop
**$99**

ceramic electric cooktop
**$299**

stainless steel electric fan forced oven
**$299**

EVERSING
AMERA KIT
ncludes all
onnection
ables, 7" monitor,
emote & IR camera
as $189 REDUCED TO
wireless kit: $199)
**$99**

**NEW GYM TREADMILL**
- Auto incline
- Cardio programs
- Cup holder & safety key
- Commercial grade
- 2 years warranty

**REDUCED TO $488**

**HEATED HYDRO THERAPY SPA**
- Computer control touch pad (50+ jets)
- Complete with pumps, filtration system
- Radion heater + recliner head rests
- Available in modern white interior polish
- 100% AUSTRALIAN OWNED company
- 100% AUSTRALIAN APPROVED

**WAS $8899**

CLEARANCE SALE $3899

**NEW THERAPEUTIC INFRARED SAUNA**

**WAS $2599 NOW ONLY $999**

NE'S HEALTH TRAMPOLINE
lock out safety net
ouble sided safety pad
trong reliable steel frame
USTRALIAN APPROVED
ft $299 16ft $399

ph: (02) 9620 9011

www.lhp.net.au

# 2012 SUMMER DEALS

## GENUINE SAVINGS

### AUTOMATIC CENTRE PUNCH
HOT DEAL

- Automatic centre punch is ideal for punching most metals, plastic & wood. No need to use a hammer just line up press
- 130mm long
- Knurled steel body

$9 (P368)
013mm DIAMETER

### SCREW PITCH THREAD GAUGE
HOT DEAL

- 23 Metric sizes, range 0.4 - 7mm
- 28 Imperial sizes, range 4 - 62TPI

$14 (Q610)
55 & 60° THREAD

### SCREW PITCH THREAD GAUGE
HOT DEAL

- Permanently etched graduations
- Brass lock nut
- Made of stainless steel
- 0-180°

$24 (Q601)
150mm LENGTH

### 4 PIECE MAGNETIC PICK UP TOOL & INSPECTION MIRROR SET
HOT DEAL

- Mirror extends 240-920mm
- Magnet tool extends 65-695mm
- Fixed & swivel magnets can carry 3.6kgs
- Fixed magnet can carry 2.3kgs

$16.50 (M0009)
SAVE $9.90

### DIGITAL ANGLE RULES
HOT DEAL

- Absolute & incremental
- Zero button
- 360° Range
- Quick lock system

$30 (M970) 180mm / 7"
$40 (M972) 280mm / 11"
$45 (M974) 400mm / 18"

### STEEL RULES
HOT DEAL

- Metric & Imperial
- Stainless steel with satin chrome finish
- Rust & wear resistant for durability

$6 (Q620) 150mm / 6"
$13 (Q621) 300mm / 12"
$19 (Q622) 600mm / 24"
$24 (Q623) 1000mm / 40"

### TELESCOPIC LED LIGHT & MAGNETIC PICK UP TOOL
HOT DEA

- 3 x LED lights
- Flexible head
- Extends 170 - 545mm
- Magnet can carry 2.27kg's

$18 (T9501)
INC. BATTERIES

## ORDER NOW!

**USE PROMO CODE: LEDSENSOR TO RECEIVE THESE SPECIAL PRICES ONLINE OR INSTORE!**

### DIGITAL SCALE WITH DISPLAY UNIT
HOT DEAL

- ON/OFF in any position
- Remembers the last setting
- Metric/Imperial switch
- Mini USB connection to the display unit

$79 (Q655) 620mm
$99 (Q667) 900mm

### PROTRACTOR - COMBINATION SET
HOT DEAL

- 4 piece set
- Metric / imperial 12"/300mm rule
- Cast iron construction

$89 (Q200)
SAVE $8.90

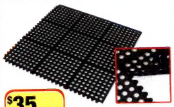
### PORTABLE VIDEO SCOPE
HOT DEA

- 1 metre cable with camera & LED lighting
- Includes: 2 metre extension cable, pick up hook, magnetic pick up tool, mirror tool

$179 (M697)
SAVE $13.50

### RUBBER MAT Clip Together - Type
HOT DEAL

- 10mm thick
- Ideal for the workshop



$35 (M909)
910 x 910mm

### DIGITAL BEVEL BOX
HOT DEAL

- Digital readout display
- 3 embedded disc magnets on base
- 0.1 degree resolution

$62 (M977)
RANGE 180°

### MAGNETIC BASE DIAL INDICATOR
HOT DEAL

- Magnetic base with on/off switch
- 0-10mm dial indicator
- Comes in a blow mould case

$69 (M055)
SAVE $8

### THREAD REPAIR KIT
HOT DEAL

- Metric (5, 6, 8, 10, 12mm)
- 11D stainless steel threads
- 1 x insert handle for each size

$149 (T100)
SAVE $14.90

Specifications & Prices are subject to change without notification. All prices include GST and valid until 29-02-12

HARE&FORBES MACHINERYHOUSE

| NSW | QLD | VIC | WA |
|---|---|---|---|
| (02) 9890 9111 | (07) 3274 4222 | (03) 9212 4422 | (08) 9373 9999 |
| 1/2 Windsor Rd, Northmead | 626 Boundary Rd, Coopers Plains | 1 Fowler Rd, Dandenong | 41-43 Abernethy Rd, Belmont |

www.machineryhouse.com.au